VOLUME 4, NO. 2 APRIL 1949

SOIL FERTILITY AND PLANT COMPOSITION ..... Roger H. Bray

MINOR ELEMENTS AS MISSING LINKS ..... Firman E. Bear

SOIL AND WATER PROBLEMS IN MEXICO ..... B. F. Osorio Tafall

CONSERVATION EDUCATION IN SCHOOLS ..... R. H. Eckelberry and Carl S. Johnson

PROFESSIONAL WORK OF SOIL CONSERVATIONISTS ..... J. G. Steele

THE LEGUME NODULE STORY ..... Joe C. Burton

EROSION DAMAGE TO RIVER AND HARBOR WORKS ..... John J. Noll

OF COURSE he can, and at any other farming operation. Why?—because Firestone Champions take a *full-traction* bite all-the-way across that massive, sturdy *full-traction* tread.

Just look at it. Notice how the higher, longer bars are curved and braced for extra bite and extra pull. No wonder they OUTpull all other tractor tires.

Underneath those rugged bars is a low-pressure tire body which runs on only 12 pounds pressure. This allows the entire tread bar surface to make full ground contact and deliver every ounce of extra traction that's built into it.

For additional proof, see your Firestone Dealer or Firestone Store.

Listen to the Voice of Firestone every Monday evening over NBC and Americana over NBC Network Television Stations

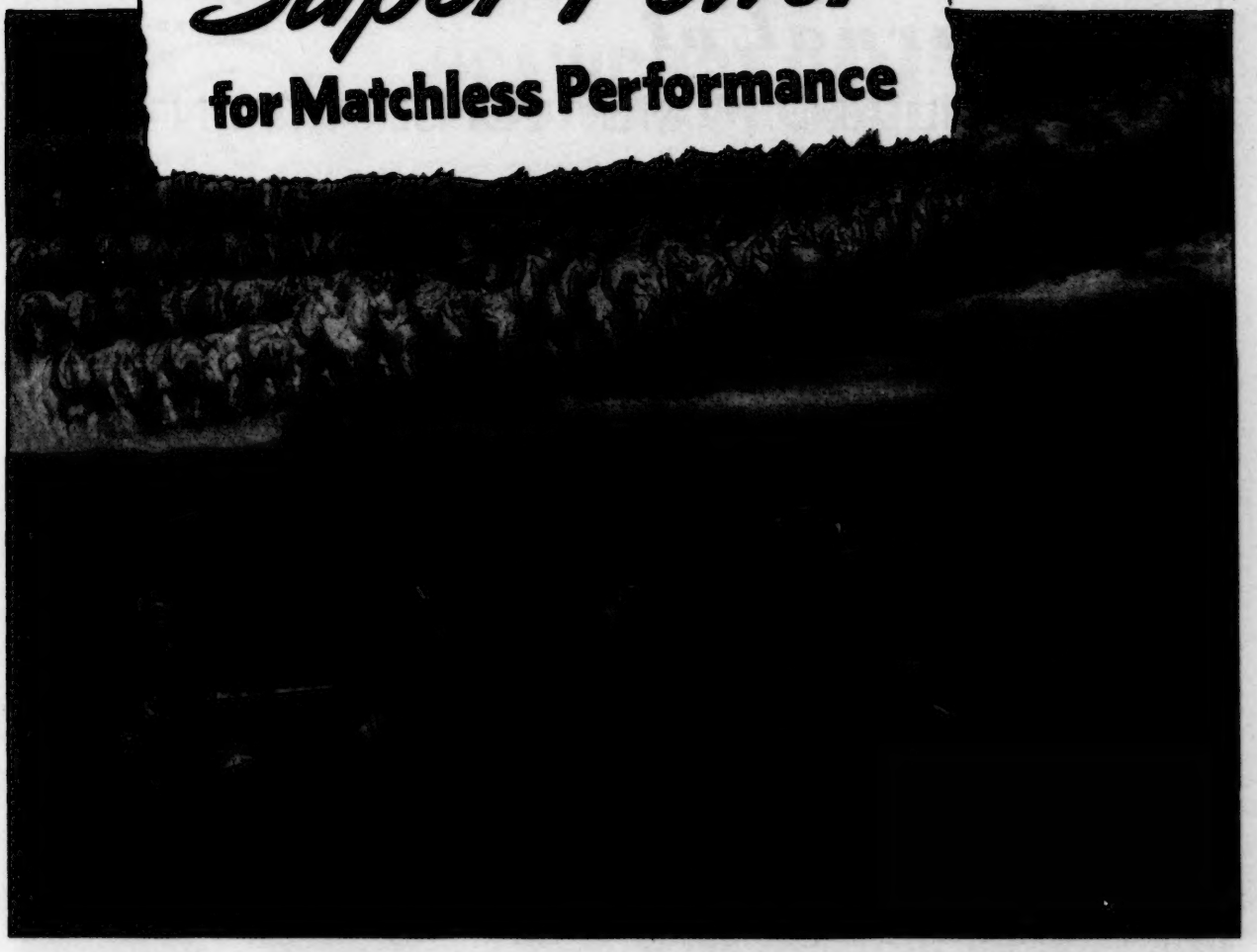
Copyright, 1949, The Firestone Tire & Rubber Co.

THE 3 RULES FOR MAXIMUM TRACTION

1. USE FIRESTONE CHAMPION TIRES
2. USE FIRESTONE HYDRO-FLATION
3. USE ONLY 12 LBS. PRESSURE

Super-Power

for Matchless Performance



The all-around operating efficiency that characterizes Austin-Western "88" and "99" Power Graders on highway work is equally noticeable and equally important on the wide variety of Soil and Water Conservation work where these machines are being used in ever-increasing numbers.

Thanks to All-Wheel Drive,* there are no idling front wheels—no dead front end to consume power and decrease operating efficiency. All weight is on driving wheels—front and rear—contributing 100% to traction and utilizing the full power of the engine.

All-Wheel Steer provides unequalled maneuverability, saves time on every job, makes it possible to work in places where ordinary power graders cannot go—to do things they cannot do.

Your nearby Austin-Western distributor will be glad to tell you the whole story of these outstanding graders.

AUSTIN-WESTERN COMPANY, AURORA, ILL., U.S.A.

VOLUME 4
NUMBER 2

Journal of SOIL AND WATER CONSERVATION

OFFICIAL ORGAN OF THE SOIL CONSERVATION SOCIETY OF AMERICA

This JOURNAL is owned, edited, and published quarterly by the Soil Conservation Society of America.

OFFICERS AND COUNCIL
OF THE S.C.S.A.

L. E. PARTAIN ..... *President*
J. H. CHRIST ..... *First Vice President*
FIRMAN E. BEAR ..... *Second Vice President*
R. H. MUSSER ..... *Council*
R. G. HILL ..... *Council*
E. H. GRAHAM ..... *Council*
G. E. YOUNG ..... *Council*
WALTER HUMPHREY ..... *Council*
J. H. CHRIST ..... *Council*
W. B. HAMPTON ..... *Council*
A. L. PATRICK ..... *Council*
RALPH H. WILCOX ..... *Council*
J. C. DYKES ..... *Council*
A. F. GUSTAFSON ..... *Council*
R. Y. BAILEY ..... *Council*
T. E. BUIE ..... *Council*

Secretary
ALVIN C. WATSON
Room 411, Center Building
Upper Darby, Penna.

Treasurer
RUSSELL G. HILL
412 Agricultural Hall
East Lansing, Michigan

PUBLICATION OFFICE: 32nd Street and Elm Avenue, Baltimore 11, Maryland.

NATIONAL HEADQUARTERS AND SECRETARY'S OFFICE: Box 1409, Spartanburg, South Carolina.

POST OFFICE ENTRY: Entered as Second-Class matter in the Post Office at Baltimore, Maryland, August 28, 1946, under the Act of March 3, 1879.

MEMBERSHIP: Annual membership is on a calendar year and is $3.00 per year of which $1.50 is for subscription to the JOURNAL and .25 cents for NOTES AND ACTIVITIES. Subscription for the JOURNAL to Libraries and others is $3.00 per year. Single copies are 75 cents each.

CORRESPONDENCE—Concerning manuscripts, books for review and other editorial matters should be sent to the Editor, Room 303, Bethlehem Building, Fairmont, West Virginia.

BUSINESS CORRESPONDENCE—Concerning remittances and questions should be sent to the Secretary, Room 411, Center Building, Upper Darby, Penna.

CHANGE OF ADDRESS: Notice of change in address should be received two weeks before the date of issue on which the change is to take effect. Both the old and the new address should be sent to the office of the Secretary.

REPRINTS: Articles appearing in this publication may be reprinted on condition that full credit be given the JOURNAL OF SOIL AND WATER CONSERVATION and the author; also the date of publication.

Contents for April 1949

Soil Fertility and Plant Composition 53
ROGER H. BRAY

Soil and Water Problems in Mexico 59
B. F. OSORIO TAFALL

Minor Elements as Missing Links 67
FIRMAN E. BEAR

Pictorial Section 69

Conservation Education in Schools 74
R. H. ECKELBERRY AND CARL S. JOHNSON

Professional Work of Soil Conservationists 77
J. G. STEELE

The Legume Nodule Story 81
JOE C. BURTON

Erosion Damage to River and Harbor Works 83
JOHN J. NOLL

Recent Research Reviews 85
JOHN H. STALLINGS

Book Reviews 87

Field Notes and Comments 90

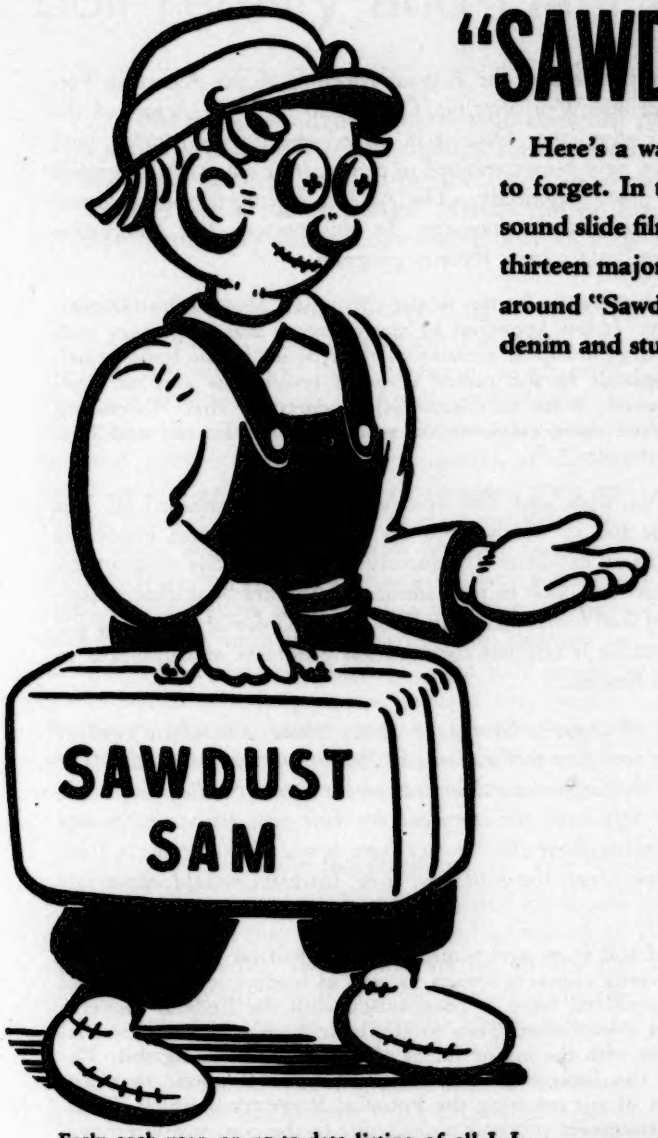
EDITORIAL OFFICE: ROOM 303 BETHLEHEM BUILDING
FAIRMONT, WEST VIRGINIA

WALTER C. GUMBEL, *Editor*

EDITORIAL BOARD

BEN O. OSBORN
LUNA B. LEOPOLD
FRED A. WIRT
DONALD A. WILLIAMS
RALPH WILCOX
B. W. ALLRED
E. H. GRAHAM
FIRMAN E. BEAR
DARRYL FRANCIS

Sells Safety with a Chuckle...



"SAWDUST SAM" SERIES

Here's a way to make farm safety lessons easy to take, hard to forget. In this new group of materials, including a full-color sound slide film, wall-chart, and cartoon mats for newspaper use, thirteen major accidents are vivid, yet bloodless. They all center around "Sawdust Sam, the almost careful hired man"—made of denim and stuffed with pure pine sawdust.

❶ Full-color slide film

Here, complete with sound effects, a narrator, and the dramatic voices of three character actors, is the full "Saga of Sawdust Sam" and his encounter with 12 sawdust-rending accidents. In the 13th accident, the dummy-hero redeems himself by saving his employer Careful Carl and the lady of the house, Safety Sally. Slide film and record are available on a free loan basis through any company branch, or direct from the educational division.

❷ Wall hanger

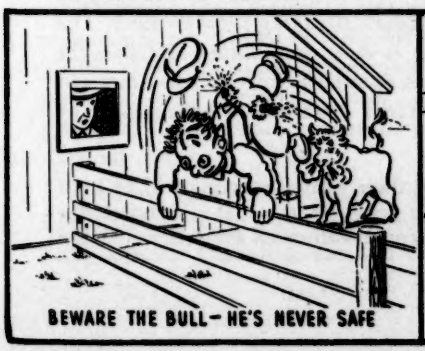
Pictures Sawdust Sam as he "learns the hard way" about six of the most common farm accidents, including the three shown below. Two colors. Available free in limited quantities.

❸ Newspaper mats

Cartoons of individual accidents are provided in mat form for newspaper or magazine reproduction. Each mat carries a title frame and 3 cartoon frames which tell a cause-and-effect story of the accident. Available free to implement dealers, newspaper editors, and others interested in promoting farm safety.

Early each year, an up-to-date listing of all J. I. Case Company visual material is published in a convenient 4 by 9-inch handbook. Remember, all of these materials are yours to use, free of charge. Write us now for your copy of "Case Visual Education Materials." Address our branch house nearest you, or the Educational Division, J. I. Case Co., Racine, Wis.

CASE


BEWARE THE BULL—HE'S NEVER SAFE

HIGH SPEEDS MAKE THE HAZARD

ONE FALL MAY MAKE A FINISH

From the Editor—

Watershed management in all its aspects will be emphasized at the Annual Meeting of the American Forestry Association which is scheduled to be held at Wheeling, West Virginia, October 10-13, 1949. A part of the program will feature a tour through the Muskingum Conservancy District in Ohio, where flood control, land use, soil and water conservation practices, and recreation have been combined to demonstrate what local initiative and leadership can accomplish in solving a problem of great magnitude. The AFA is placing considerable emphasis on local enterprise and its responsibility to community development. In this respect, the Association strongly favors a national land policy upon which it can build a basic forestry program.

The Land Policy statement developed and approved by the Society at the Cincinnati Meeting last December has been widely publicized throughout the country. It has appeared in many papers and magazines with strong supporting statements. Conservation and farm organizations, because of their belief in the basic principles that it contains, have supported and given emphasis to the policy through resolutions and editorial comment. The Pennsylvania Forestry Association noted in its resolution of concurrence that "increasing populations make it imperative that a land policy, based upon conservation principles of wise use and husbandry, be developed and accepted by the American people."

A very fine book by Dr. Lionel Picton entitled *Nutrition and The Soil* has just been published by The Devin-Adair Company. It emphasizes the fact that the soil in which crops are grown is the most important factor in creating human health. The book also contains an excellent introductory essay on creative medicine by Dr. Jonathan Forman. Conservationists will want to add this book to their libraries. Another book that conservationists will want to obtain is entitled *The Practice of Soil Conservation in The British Colonial Empire* by Sir Harold A. Tempany. It too is highly informative because it outlines conservation programs and practices in detail and the effect that they are having on the British Empire.

The Limestone Valley Soil Conservation District of Dalton, Georgia, recently issued a brochure entitled "Our Soil and Water Conservation Program." It is a very fine publication and clearly sets forth the local land use and management problems in the district and what the farmers are doing to correct them. Publications based on programs in effect are valuable because land owners help write the story and by their own actions encourage others to do likewise. Many soil conservation districts throughout the country have issued similar reports from time to time. Because of their value in passing along new ideas, the Editor of The JOURNAL *would appreciate receiving copies for review purposes.*

The abatement of stream pollution in the form of soil from agricultural lands, industrial wastes, and raw sewage presents a problem of great magnitude. It concerns conservationists as well as leaders in industry and other enterprises. Many states, in trying to solve the problem, have in cooperation with the Federal Government and other groups, formed inter-state compacts on a watershed basis to eliminate such pollution. Special committees are being formed within each group to cope with the major forms of pollution including soil. Dr. Harold A. Kemp recently told the Land Committee of the Inter-state Commission on the Potomac that turbidity tests showed no apparent decrease in the amount of silt reaching the Potomac River from which Washington, D. C., must depend for its water supply. This statement presents a challenge to the conservation movement not only in that area but elsewhere, and emphasizes the fact that here is another vehicle through which "grass roots" conservation can be achieved. There are approximately 80 watershed development groups in existence throughout the country.

The Road to Conservation by Whitney R. Cross is the subject of an article in the Winter 1948-49 issue of the *Antioch Review* in which the author discusses the relationship of conservation and democracy by referring to and analyzing six recent books. They are: *Road to Survival, Our Plundered Planet, Breaking New Ground, The Great Forest, Farming and Democracy* and *The Missouri Valley.* The article is most stimulating and thought provoking. It should be widely read because of the issues raised. The author is Assistant Professor of American History at Smith College and is writing a history of changing American attitudes toward the management of land and other national wealth.

From the American Society of Agricultural Engineers comes word that their annual meeting will be held on the campus of Michigan State College, East Lansing, June 19 to 23. The program as usual is outstanding and features a section on Soil and Water at which many papers by leading conservationists are scheduled for presentation.

Soil Fertility and Plant Composition

ROGER H. BRAY

Nutritious food depends on the chemical properties of the soil. This means that either we learn to scientifically fertilize plants for the production of food adequate for survival, or we reduce our world population by the slow process of starvation until finally we reach a balance with nature's way of doing things. Nature can no longer cope with the pace man has set—in the future fertile soils can remain fertile only as man learns, through science, to keep them fertile.

BECAUSE WE HUMANS depend on the food we eat to supply us with all the essentials for growth and health, it is small wonder that so many of us are interested in whether or not our food really is doing the job we expect of it. And it is because the nutritiousness of our food depends on the chemical properties of the soil that I am here as a soil chemist talking about plant nutrition. However, it is that phase of plant nutrition commonly called soil fertility, a phase in many ways very different from the classical approach to plant nutrition, that I will talk about today. Soil culture-plant relationships have many phenomena which are not common to solution culture-plant relationships. The final product can be similar but the processes involved vary greatly. Among the essentials contributed by plants to animal and human growth are the so-called essential mineral elements and our talk today will be mainly concerned with them.

Soil-Plant Relationships

The natural source of all elements essential for *animal* growth is the food they eat. The natural sources of all elements essential for *plant* growth are the air and the soil. Except for nitrogen, the natural sources of the elements supplied by the soil to the plant are the primary rocks or rock material in the soil.

Now it so happens that in general some elements are more abundant in soil-forming rocks than others. Some are generally present in relatively high total amounts. Others are present in relatively small amounts or traces. As examples: calcium, potassium, and magnesium belong in the former group and copper, zinc, and boron in the latter group.

Continuing our examples: calcium, potassium, and magnesium are needed *in relatively* large amounts by plants. They are called major essential elements. Copper, zinc, and boron are needed in extremely small amounts by plants and, for this reason, are called minor essential elements.

Then we have other elements—iron is an example—which are present in soil-forming rocks in relatively large total amounts but which are also called minor or trace elements because they are needed by the plant, and usually occur in the plant, in very small amounts. Thus, the relationship between the relative amounts of the mineral elements needed by plants and their relative amounts in the soil is not so consistently a direct relationship as might have been expected.

One might well ask—Why has the plant chosen only a few of the elements present in relatively large amounts in soils for its major elements? Why the discrimination against iron and aluminum and silicon? Because their properties are such as to make them unsuitable for their use in the plant in large amounts? This is probably a part of the answer but it may not be the whole answer. The chemical properties of soils may throw some light on this problem.

In soils it is not the total amount of an element in the soil which determines how much a plant can obtain. Instead, the relative amount a plant can take up depends mainly on the amount of each element present in the *available form or forms* in soils. But the ability of a soil to renew these available forms, as they are removed by the plant or lost by leaching over the ages, does depend on the nature and amount of the total supply. So indirectly but not proportionately, and from the long time viewpoint, the amount present is related to the total supply.

However, the *available* supplies of the elements are also related to their chemical properties. The chemical properties of iron and aluminum and manganese, for example, are such that, except in the more acid soils and hence, in general, in the more weathered and more infertile soils, they *cannot* exist in relatively large amounts in the available forms. Therefore, any plants adapting themselves to a relatively high requirement for iron, for example, would not be able to exist on the majority of

This paper by Dr. R. H. Bray was presented at the Annual Meeting of the Soil Conservation Society of America held at Cincinnati, December 9-11, 1948. Dr. Bray is Professor of Soil Fertility and is on the staff of the Department of Agronomy, University of Illinois, Urbana, Illinois. His studies in soil fertility have resulted in more than 60 papers in the agricultural, chemical, ceramic and geological Journals; also a chapter in *Diagnostic Techniques for Soils and Crops.*

the more productive soils of the world but would have to be restricted to acid soils.

So we find, generally speaking, that the major essential elements for plants are also the ones *whose available forms* can and do occur in soils in relatively large amounts. And, in general, the minor elements are ones whose available forms are present in relatively small amounts in soils.

Plant-Animal Relationships

Now let us consider the relationship between plant and animal needs. With a few apparent exceptions, they both need the same elements. Among the so-called major elements, that is, those needed in relatively large amounts, all those required by plants are also essential for animals. In addition, animals also require sodium and chlorine in relatively large amounts. Among the so-called minor elements needed in relatively small amounts the ones generally recognized as being needed by both plant and animal are iron, copper, manganese, and zinc. Animals also require cobalt and iodine, while plants require boron and molybdenum. Further research may at any time establish the essentiality for either plant or animal of additional elements contained in plants in minor amounts.

Soil-Animal Relationships

Thus, it is as though animals have, through their dependence on plants as food, adapted their *essential element requirements* to the relative amounts found in available form in soils. And with very few known exceptions throughout the world, plants do not poison animals by soil derived elements. It is as though animals have adapted their *tolerance to an excess* of any element to a level higher than that which will ordinarily be furnished them from the soil by plants. Selenium poisoning in our West and molybdenum poisoning in Scotland are localized exceptions.

Plants vary in their relative mineral requirements and hence, vary in their composition. Animals also vary in their relative mineral requirements, hence, they vary in their ability to obtain sufficient amounts of each element from, for example, a pasture of mixed plant populations. If a day's consumption of food does not contain, on the average, the daily requirement of each element, the animal's growth is restricted, and health endangered. As with plants, deficiency diseases in animals occur and are recognized only in extreme cases. Moderate mineral deficiencies go unnoticed except as measured through growth trials by a trained nutritionist. Animal and man still depend on their food to supply practically all of the essential elements.

How far can we go in assuming that our soils will put enough of each *animal* essential element into our crops so that they in turn will be adequate foods for animal and human nutrition?

Soils Often Deficient in Major Nutrients

In the case of the major elements, we know that very few of the soils of the world are well supplied with all of them. Deficiencies of phosphorus, nitrogen, or potassium for plant growth are common all over the world. Virgin soils often possess only a superficial fertility, inadequate for maximum plant growth and composition except for a short time. This being the case, it is perhaps plausible to assume that, in general, animals have adapted their needs to a level which they can obtain from the crops they eat. These crops in turn are growing on soils just adequate or perhaps only moderately deficient in the major elements needed for plant growth. So if the available elements in a soil are about adequate for optimum yields and maximum composition, one might expect the crops growing on it to furnish adequate mineral supplies to the animals consuming those crops. This, in fact, has apparently been generally assumed in the past.

Soils Seldom Deficient in Minor Elements

How about the minor elements? We have no recognized areas of widespread deficiencies of the minor elements as far as their effects on yields of crops are concerned. Most minor element deficiencies are limited to localized areas of well-weathered soil or soils from parent materials especially low in one or more of these elements. This can mean that the minor element content of plants, in general, represents luxury consumption. If animals have adapted their own mineral needs to the amounts contained in plants in quantities in excess of the actual needs of the plant, then they cannot obtain sufficient of that element when the plant no longer takes up more than it needs for maximum yields.

Plant Sufficiency May Not Mean Animal Sufficiency

So we can raise this question—will the fact that a crop does not give a growth response to an application of a minor element insure an adequate amount of that element to the animal eating that crop? It can well be that, due to luxury feeding by crops in the past (compositions higher than needed), animals have adapted their needs for some of the minor elements to a level higher than can be secured from crops growing on soils not plant-deficient in those elements. So far it has not been established that cobalt and iodine are needed by crops, yet the animals depend on plants for cobalt, and a cobalt deficiency disease is produced when animals depend on crops grown on certain soils. In such cases the crop need *is* lower than the animal need, perhaps to the point where the need is nonexistent for the plant. But they illustrate

the possibility that *crop needs can be lower than animal needs.*

Thus, we can talk of soil deficiencies for plants *or* for animals. Plant deficient soils are ones which do not supply to the plant adequate amounts of one or more of those elements essential for that plant's optimum growth. As a result yield and composition decline. Animal deficient soils are ones which do not, through the plants growing on them, supply adequate amounts of the elements essential for animal growth and health, when the animal depends on those plants for its food.

As illustrations, certain soils in Australia are animal deficient in cobalt; certain soils in Illinois are plant deficient in boron; and certain soils in South Africa are both animal and plant deficient in phosphorus.

It is now common practice to add not only sodium chloride to the diets of our modern livestock bred for rapid growth and high production, but also under certain situations to add calcium carbonate and calcium phosphates to increase the calcium and phosphorus uptake. Thus, modern livestock production methods recognize that two major elements, calcium and phosphorus, are not now being obtained in adequate amounts under some situations from the plant food consumed. Since minor elements are often associated with the enzymes functioning in growth, the question can also be asked—are larger amounts of *minor* elements required today than were needed years ago?

The Recent Interest in Nutrition

Recently we have seen an awakened interest in nutrition, especially human and animal nutrition, on the part of both the research worker or scientist and also the layman. Because the scientists have traced so many diseases to deficiencies of one or another of the essential elements, speculation has been raised as to the extent of the undiscovered relationships which may exist between the present bodily ills of man and essential element deficiencies. In the minds of some laymen, these speculations have even crystallized into unfounded certainties. On the part of the research worker, these speculations are unanswerable because of a lack of knowledge, a lack which is a part of the process of research. Each new finding in scientific research always raises more questions than it answers and it always will. It now appears that the scientist is being blamed for having raised questions and speculations which he cannot answer without further research. But this appears to have its good side. It has stimulated thinking by both scientist and layman. It may finally give the layman a picture of the possibilities, through research, of solving the problems raised.

Perhaps in time we shall have these interested laymen behind us in a great soil-plant-animal research program aimed at solving these problems, a program already started in small way in the federal Soil-Plant-Animal Nutrition Laboratory at Cornell University.

When these problems are solved we should be able to answer the following questions:

(1) What are *all* the elements which are essential to plants and/or animal nutrition?
(2) What part do they play in nutrition?
(3) What amounts are needed in the daily ration?
(4) What amounts are needed in the soil?
(5) What plant or animal diseases are caused by a deficiency of one element or combinations of elements and what other food factors needed by animals are deficient in plants grown on mineral deficient soils?
(6) How can these elements be controlled and balanced in the soil so that maximum yields of nutritious food crops can be produced?
(7) How can they be controlled and balanced in animal and human feeding for maximum growth and health?

Attacking the Soil Problem

From the viewpoint of a soil chemist I am going to try to outline the type of research work which I think is needed to answer the question, "How can these elements be balanced and controlled in the soil so that maximum yields of nutritious food and feed crops can be produced?"

In the first place, because *plant composition and yield depend on the available forms of the elements in soils,* we need to find out the nature and properties of these available forms of the essential elements. Then we must find methods, especially rapid methods, of measuring the amounts present in each farm field. We can do this accurately today for only a few major elements, especially phosphorus, potassium, calcium, and magnesium.

Next we must correlate the amounts present in the soil with crop deficiencies. We have done this in an exact way only for phosphorus and potassium, but in doing so we have set a pattern which future research can follow in an attempt to get the correlations now needed for the other essential elements, either for plants or animals. After all, a soil test can be correlated not only for plant growth, but also for animal growth, *if the animal nutritionist will tell the soils man how high a concentration of any element is needed in the plant which he feeds to the animal.*

Now let us consider the results of the work already accomplished and the implications of this work.

Today in Illinois we have 67 county soil testing laboratories, all testing soils for acidity (limestone needs),

phosphorus, and potassium. After the tests are made, our county agents can tell each farmer how much limestone, phosphorus, and potassium he needs, and in addition he can tell the farmer the exact percentage his yields are being cut or held back by the phosphorus and potassium deficiencies. For example, if the soil phosphorus is only 70 per cent sufficient and the soil potassium is 80 per cent sufficient, then 70 per cent of an 80 per cent yield or a 56 per cent yields will be obtained. Yields are being cut by 44 per cent.

Now on the average a fertile soil will produce, through the years, a crop of a certain average mineral composition. As soil fertility decreases the average mineral concentration in the crop decreases. A crop growing on a soil only 70 per cent sufficient in phosphorus will contain less phosphorus in its tissues than one growing on a soil 100 per cent fertile. Since soil tests can measure these per cent sufficiencies, then there is a good possibility that the soil tests can also be interpreted to tell the farmer the composition of his crops as well. Not that the farmer would always be interested in crop composition but his neighbor who buys his grain or hay for feed will be. Crops grown on soils where none of the elements are deficient, either for total yield or composition, may be assumed to be not only relatively high in each essential element, but also to possess the best quality with respect to *all the other food values*. At least I do not know of any evidence to the contrary.

Until we find that this assumption is false and that the amounts of the minor elements in crops and the quality of the other food values are not affected by soil deficiencies of one or more of the elements, we must continue to be concerned with the maintenance of optimum fertility with respect to all essential elements, both major and minor, both plant and animal.

Now it is known that yield alone is not an adequate guide to composition. Highly fertile soils can produce low yields due to a combination of a poor season and a physically inferior soil type. The recorded extremes in yield in Illinois *on fertile soils,* due to the physical nature of the soil and the season, are four bushels and 138 bushels of corn. Both yields were grown on soils not deficient in the available forms of the essential elements. Also high yields have been produced from infertile soils, soils highly infertile in one essential element. Sixty-eight bushels of corn is a relatively high yield for a soil highly deficient in potassium when the Illinois state averages are around 50 to 55 bushels. Yet it is a *relatively low* and deficient yield when compared with the yield from the adjacent soil where, with potash made adequate, a yield of 107 bushels was obtained. On the other hand low yields can be produced due to slight deficiencies in several elements, yet the final product will not be much lower in composition for any one element.

So we must distinguish between yields from soils seriously deficient in one or another of the essential elements and those yields which, although even smaller, may come from soils *not* seriously deficient in any element.

It is not good science to claim that low yields are from deficient soils or that high yields will be of a good composition. It is the physical nature of the soil and the season which set the yield possibility for a given crop. Low yields may be due to low yield possibilities on *chemically* fertile soils. High yields may be due to very high yield possibilities on soils deficient in one or more nutrients.

Analytical Laboratories Needed

Because the laymen have heard about soil testing and plant analysis as guides to fertility and nutrition, a great demand for analytical services has been created. In a few cases it is a timely demand. Analyzed mixed feeds are now on the market. At least they are analyzed for a few food values. Yet most feeds are not mixed and are not analyzed. Soil tests are being made for a few of the available forms of the plant essential elements. But our knowledge is limited. We can analyze and make interpretations (and without interpretation, analysis would be useless) for only a few of the elements or food values. A total analysis of a soil is usually useless. It is the available form of an essential element that controls the growth and composition of plants. Yet total analyses may be helpful in a few extreme cases in pointing to *possible* deficiencies of some minor elements—i.e., those which are usually relatively low in both the *total and available forms.*

More of these total analyses of soils are being made outside of our experiment stations than inside, sometimes by those who pretend to more knowledge in their interpretation of the results than they can possibly possess.

So while we need analytical laboratories (either within or outside of our state and federal experiment stations), which can service laymen and research men alike, *we need even more the research through which the analyses can be interpreted.*

The total analyses of crops for mineral elements could give us the compositions normal to fertile soils, extremes could be eliminated and the average of the upper 25 per cent of the values used as a tentative guide for fertilizing farm soils. Soils producing farm crops which were found to contain less than these amounts could be safely fertilized with limited amounts of the minor elements or the usual amounts of the major elements and the crops again analyzed. Through this process at least

tentative procedures for maintaining crop composition at the levels found in the more fertile soils could be established.

This procedure would also make it possible to secure soil samples from soils which had produced crops of a known composition. From soils varying in their contents of any element, whether or not essential for the plant, samples could be selected in order to study the chemical nature of the available forms of these elemnts and to invent extracting solutions which could remove these available forms so they could be measured. Once this is done, as it has been done already for a few elements, the soil tests could then be used to control the soil level of each and every nutrient in order to control plant composition either as a means of securing highest yields or as a means of securing certain compositions and balances between the elements in the plant which would be favorable for animal growth. The idea of having a central analytical laboratory where analyses for such studies could be made is now being promoted by various groups. Mr. Arnold Yerkes of the International Harvester Company has already described what, in his judgment, such a service laboratory should be like as well as its purpose, and he foresees its establishment by funds from industry. Such a laboratory could help accomplish a great deal. But in order to do so, it would have to have the guidance of specialists in soil chemistry and plant and animal nutrition. These specialists must pool their knowledge in this attempt to find methods by which the farmer can control yield and quality in order to obtain nutritious crops for animal and man. Analyses for the laymen would only be helpful where, through research, the results could be interpreted.

That such a laboratory could eventually do much good is strongly indicated by the fact that Illinois now has over 70 chemical laboratories doing service soil analyses for farmers for limestone, phosphorus, and potassium.

There are many things which need to be considered in the development of such a research program as I have mentioned above. In the first place, the soil chemist has as one objective—the obtaining of high yields. He would like these yields to represent crops as suitable as possible for animal food. He has to use major and minor elements to produce these foods. It is up to the animal nutritionist to warn him against the misuse of these elements from the standpoint of their wrong content and balance in food plants. Many essential elements if present in large amounts are poisonous to plant and/or animal and must be used with caution. Furthermore there is the undecided problem—should the plant be enriched if the nutritionist is going to use complete mineral mixtures anyway in animal feeding? From the soil chemist's viewpoint it is perhaps the job of the animal nutritionist to solve this problem. Plants *have* to contain certain amounts of most of them, and if these are not enough, the nutritionist could use supplements. But in supplementing the nutritionist has to know the composition of the food he uses unless it so happens that he can supplement safely regardless of the crop's content. So the soil chemist would welcome the cooperation of the animal nutritionist in solving this problem. The soil chemist does not want to ignore the crop as a source of food for animals.

Soil Conservation and Soil Depletion

Now where does soil conservation come into this picture of plant nutrition through the soil? There is at present a school of thought which believes that soil erosion is normal, that commercial fertilizer supplies are limited and that the soil itself is a vast reservoir of all the essential nutrients which should be tapped and utilized and then renewed from below by slow erosion. This is nature's way of responding to infertility, therefore, desirable. Then is soil stabilization by conservation measures undesirable?

There are serious faults in this erosion concept. In the first place the "vast store of essential nutrients" in soils is contained largely in the unavailable mineral and organic matter forms. These forms become available only through weathering and decomposition. If we destroy organic matter, we destroy productivity. If we wait for minerals to weather, we may die of malnutrition during the process. Soils have been eroding faster than even this school of thought would advocate, yet I have seen no evidence that this erosion has increased or maintained the fertility and the productivity of the soil. The evidence is all on the other side.

The results of fifteen years of full time research by the writer and his associates concerned with the study of the chemistry of soil development from the time development started up to the present has failed to show that in general the weathering of the minerals in the soil can be relied upon for the maintenance of a productivity high enough to keep our present population alive. I will cite one illustration. The calculation of the weathering rate of the potash minerals in Illinois soils, based on the unweathered loess, shows that if the interval since loess deposition is 50,000 years, then each year only one-fifth of a pound of potassium per acre, 6 2/3 inches (2,000,000 pounds of soil) has been released by weathering.

Our crops in the corn belt are not growing on nutrients that are being released from the minerals each year. They are feeding from relatively large supplies which have accumulated under natural conditions during past centuries. As these amounts are used up, fertility

has to decline and is declining. It is declining more slowly where the soil has large supplies of the unweathered minerals, but it is still declining.

But if we keep nature's remedy from working or slow it down by soil conservation measures, we must face the consequences. Soil conservation practices are designed to produce higher yields. In any one season the yield possibility is determined by the physical qualities of the soil. Preserving the natural surface soil preserves, in general, the part with the best physical qualities, hence higher yields. Higher yields mean a greater removal of the available nutrients from the soil. Because of higher yields, soils stabilized against erosion are more readily raped of their fertility. This is one consequence of soil conservation practices. If lime and legumes are added to the program, yields are still further increased and rape of the soil, except for the calcium and magnesium added in the limestone and nitrogen fixed by the legumes, proceeds at a still higher rate. For every essential element but nitrogen, calcium, and magnesium, the lime legume program used alone is the most soil depleting program we have. It builds up productivity while depleting fertility—unless it is accompanied by a *fertility conservation and building* program, including the return of crop residues, animal manures, and mineral fertilizers where needed.

And in the meantime we are also pumping out of our rich soils the available supplies of the minor elements needed by plants and animals—elements which may not now be deficient but, under a stabilizing soil conservation program, will become so if appropriate measures are not taken.

Solving the problems raised in this paper are of just as much importance to the soil conservationist as it is to the research workers in soil fertility and animal nutrition.

The solving of the problems, as suggested above, is a scientific approach, and yet there are those who would have us believe that through science alone we cannot hope to continue to produce nutritious crops—complete foods for animal and man; that only nature can do this.

It may be true that if plant and animal and man were to attend to their own breeding problems by natural selection and if nature solved all fertility problems by active erosion, we could eliminate the problems we have created. But to do so we would have to back-track to the dark ages when nature fed plant, animal, and man and determined populations.

Today we are at the cross-roads—either we learn how to scientifically fertilize plants for the production of food both quantitatively and qualitatively adequate for our survival, or we reduce our world population by the slow process of starvation until finally we reach a balance with nature's way of doing things. Nature can no longer cope with the pace man has set—in the future fertile soils can remain fertile only as man learns, through science, to keep them fertile.

Egypt's Population Growth

The pressure of Egypt's rapidly growing population on her very exiguous soil has been preoccupying Egyptian economists and sociologists during the last fifteen or twenty years. But the problem is not peculiar to Egypt; it is part of a world-wide phenomenon which can be seen equally well in India or Indonesia today or in Western Europe during the 19th century. Briefly put, the population of these countries is growing, or has grown, because the secular balance between births and deaths has been upset. For in a pre-industrial society the death rate is always high, owing to inadequate nutrition, defective hygiene, the spread of epidemics and the loss in lives resulting from disorders and wars. In order to compensate for this high wastage the society favours those customs and institutions that promote a high birth rate, such as stigmatizing celibacy, encouraging marriage at an early age, honoring parenthood and so forth. When as a result of the spreading of industrial civilization, order and security prevail, hygienic conditions improve and more food becomes available, the first effect is a decline in the death rate. The birth rate, however, which is determined mainly by social and religious factors, remains for a long time at its previous high level. It is only when an industrial civilization has prevailed sufficiently long to change the whole customs and outlook of the population that birth rates begin to decline, as they have been doing in Western Europe and North America. Egypt is at present in the first stage, the stage of declining death rates unaccompanied by falling birth rates.

As a result of these factors, the population doubled in half a century, standing at about 6,800,000 at the time of the British occupation in 1882. . . . The reported population of 1947 (19.04 million) is generally believed to be inflated but it is very unlikely that the true figure is lower than 18,000,000 which would give an increase of about 13 per cent over the decade. . . .Two facts should be borne in mind. First, Egypt's population has increased six-fold during the last hundred years, from about 3,000,000 to some 18,000,000, a rate of growth probably unparalleled by any purely agricultural country. Second, Egypt is perhaps the most densely populated country in the world.— Charles Issawi, Milbank Mem. Fund Quart., Jan., 1949, as reported in the Journal of Heredity, Feb., 1949.

Soil and Water Problems in Mexico

B. F. OSORIO TAFALL

Mexico is faced with the urgent necessity of stabilizing her agricultural production to rid herself of the periodic food scarcities and hunger that have devastated the country in the past. Because of this situation, a land use and wide-spread conservation program has been established. It promises to increase the productive capacity of the soil and also contribute greatly to better social and economic conditions of the farming class upon whom the country depends.

THE CONDITION OF THE LAND that the present Mexican generation has inherited could not be more discouraging. It has given reason to distinguished conservationists, familiar with the tragic reality of the country, to state that Mexico, despite her considerable surface area of 2,000,000 square kilometers (70 per cent of which is mountainous and the remainder flat or gently sloping) and her relatively small population (22,776,041 inhabitants, according to the 1946 census, 6,000,000 of whom are gainfully employed), may be considered an over-populated nation because of the low productivity of the lands under cultivation.

Not more than twelve per cent of the total surface area of the Republic is under cultivation or is suitable for tilling. Cultivated areas, however, as a result of destruction of topsoil and a decline in fertility, have gradually been losing their productive capacity because of man's abuse. Now—and this situation has become more acute in recent years—the Mexican land cannot support the great mass of her people. For each individual there is available no more than one-third of the amount of land necessary to support him adequately.

Classification of Surface Area of Mexico

	Hectares	Per cent
Cultivated and arable area	23,400,000	11.92
Grasslands on plains and hillsides	66,500,000	33.86
Grasslands on mountainous regions	30,000,000	15.27
Forest area	45,000,000	22.91
Desert area, not suitable for agriculture	31,500,000	16.04
Total area	196,400,000	

It cannot be denied that there has been a growing consumption of foodstuffs owing to the increase in population, the rate of which has been augmented in recent years as a result both of improved sanitary conditions (the population increase during the decade 1937-46 was 2,000,000) and of a higher standard of living among certain sections of the population. On the other hand, crop yields have not followed a like curve, but rather have either maintained the same level or, what is worse, have shown a decisive decrease. The best indication that Mexico, under present agricultural conditions, is incapable of fulfilling the food requirements of an underfed people even with the large importations of staple foodstuffs, such as wheat, corn, sugar, fats, etc., that must be made year after year.

There are many facts revealing this unfortunate situation, but perhaps there is little evidence more credible than the annual exodus of farmers who, despite their love of the land that gave them birth, eagerly and often illegally attempt to emigrate to the United States as day laborers. Mexico's food situation, precarious as it is, will probably become considerably worse because, even under optimum conditions, that is, by combining the cultivated area and the cultivable area (23,400,000 hectares) and leaving not a single hectare untilled, the indispensable minimum per capita would hardly be achieved. Such an ideal situation is considerably far from reality, inasmuch as at least 7,000,000 hectares of agricultural land are, to a greater or lesser extent, affected by erosion.

Causes of the Present Situation

Ancient cultivation practices of the Mexican Indian, poor land use during three centuries of colonial rule and in present-day Mexico, immoderate exploitation of forests, accentuated in recent years, all have caused either a reduced production potential of a high percentage of Mexico's cultivated or arable lands, or destruction through erosion of fertile topsoil. The damage that the human impact has produced in a country like Mexico, of such singular climatic characteristics, with her vast arid and semi-arid areas, deficient in rainfall during crop season (Figure 1), makes soil conservation and problems of increased productive capacity truly difficult to solve.

Down through the ages Mexican farmers have treated

B. F. Osorio Tafall is in charge of the Natural Resources Section of the Banco de Mexico. Preceding this assignment, however, he was head of the Biology Office of Guanos y Fertilizantes de Mexico. Mr. Osorio is interested in general ecology and has published many papers on birds and marine biology of Mexico's West Coast.

The original paper was translated from Spanish by Annette L. Flugger, Pan American Union, Washington, D. C.

the soil without any kind of consideration or thought. The Mexican land bears inscribed on its surface the abuse to which it has been subjected for century after century. Mountain regions that two hundred years ago —and in some places even less—were covered with dense forests have completely disappeared under the implacable attacks of the woodsman, the charcoal maker and the lumberman. What were formerly great areas of verdure are today vast barren spots through which bare rock gleams forth. Lands famous in yesteryear for their fertility are today unsuitable for cultivation because erosion has opened deep incurable wounds in the heart of the soil. Vast plains that in times past were natural pastures today will support no more than a rachitic vegetation totally inadequate for man. Rivers that formerly flowed crystal clear, where plant and animal life flourished, are now desultory, muddy streams carrying to the sea the lost fertility of the land. The destruction of the soil's protective plant cover, especially on the slopes, changed the hydrographic regime of many rivers, with a consequent effect on the amount and erosive power of runoff, increase of siltation, diminution of volume of water during the dry season, and greater frequency of floods and inundations that ruin, with silt deposits of little or no fertility, the rich soil of the coastal plains. Man's impact on the land, because of the ignorance of not only one generation, but a succession of generations, of the way to manage profitably that precious treasure, land, has wrought irreparable damage.

Those who have toured various states of the Republic have undoubtedly acquired a keen consciousness of the unhealthy condition of vast areas of cultivated land. The Mexican people are just beginning to realize that great expanses of national territory are totally destroyed by erosion. No measures have been taken to date, either on the part of individuals or government agencies, to combat or remedy the harm done by this greatest of evils affecting man's most indispensable of properties. The causes of such a condition of the soil are the same as those studied in other countries and evidenced in Mexico perhaps more seriously because native cultures from the remote past established the cultivation of the land.

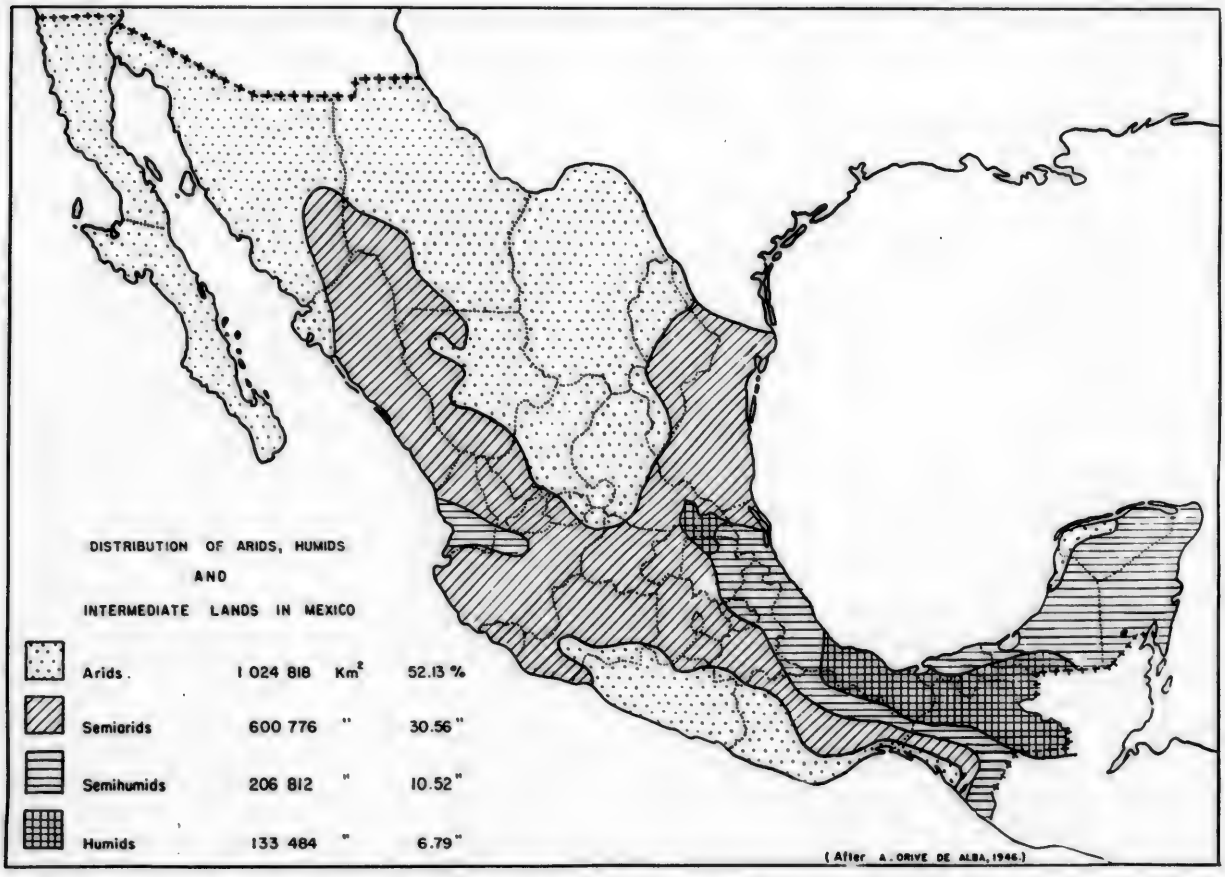

DISTRIBUTION OF ARIDS, HUMIDS
AND
INTERMEDIATE LANDS IN MEXICO
Arids. 1 024 818 Km² 52.13 %
Semiarids 600 776 " 30.56 "
Semihumids 206 812 " 10.52 "
Humids 133 484 " 6.79 "
(After A. ORIVE DE ALBA, 1946.)

Figure 1. Mexico with her vast arid and semi-arid areas, deficient in rainfall during crop seasons makes soil conservation and problems of increased productive capacity truly difficult to solve.

Figure 2. Man's impact on the land as shown in this scene near Mexico City, because of the ignorance of generations not knowing how to manage the land, has wrought irreparable damage.

The measures that should be taken to correct such a state of affairs are difficult since they require a long time, great expense and a strong national awareness of cooperation, and the factors that favor erosion and impede its control are many and varied. Among those to be considered primarily are unfavorable climatic conditions, topography of the land, inadequate land use, and existing ethnic and social conditions that increase the gravity of soil erosion problems.

The Sick and Thirsty Land

Only seven per cent of Mexico's land lies within humid zones where the annual amount and distribution of rainfall are sufficient for agricultural needs. Irrigation works are unnecessary in these areas but, on the other hand, the zones are extremely unhealthful, and intensive agriculture cannot be carried on without undertaking costly and complex sanitation projects that would enable large peasant populations to be settled on lands that are potentially the richest in the country. Only in these regions and in the irrigated valleys is it possible to carry on a diversified agriculture in which land-use conservation programs might be successful. The rest of the country, or 93 per cent of the total surface area, comprising the arid, semi-arid, and semi-humid zones, possesses particular characteristics that are opposed to the development of diversified agriculture and are difficult to adapt to soil conservation programs. Of the 24,000,000 hectares of arable land in Mexico, only 2,000,000 receive the necessary amount of rainfall, 7,000,000 can be irrigated (efforts to date, first by the National Irrigation Commission, and at present by the Ministry of Water Resources, have resulted in placing 1,000,000 hectares under irrigation), and for some 15,000,000 hectares there is no alternative other than to put them in seasonal cultivation under very uncertain conditions.

Distribution of Surface Area Available for Agriculture

	Hectares	Per cent of total
Cultivated and Arable Area		
cultivated	7,265,560	3.70
fallow	7,352,209	3.74
arable	8,839,000	4.51
Surface area available for agriculture	23,456,769	11.95

Mountainous areas and grazing lands located in arid and semi-arid regions cannot support even monoculture. In regions where the topography is extremely irregular, with long steep slopes, very thin soils and two definitely marked periods of alternating drought and rain, seasonal agriculture can be nothing more than a very rachitic monoculture. Under such conditions, to plow the soil means only to subject it to erosion. Because it is best adapted to these changing conditions, corn culture has come to dominate vast areas, displacing the forest cover

on mountain ranges and the grazing lands on semi-arid plains, and causing through torrential waters the siltation of the thin layers of original soil.

Rainfall is never an aid to soil conservation but rather, in many cases, a contributing factor in hindering the control of erosion. Semi-arid zones that cannot be put to intensive use and whose native vegetation is poor, are subject to torrential rains that carry in their wake the bare, exposed soil and, except in the case of irrigation projects constructed to utilize these waters, they leave nothing in their path but erosion. These rains, at times occurring over very short periods with extraordinary intensity, are assisted in their destruction by the slopes over which they flow. With two great mountain ranges approximately parallel to the coasts, the transverse volcanic axis uniting them, and a plateau with very irregular topography, the courses followed by these copious periodical rains are nothing but paths of little value; but on the other hand of enormous siltation, leading to the depths of the ocean.

Almost the entire volume of precipitation in this storm area is runoff water. Rainwater is not controlled except in regions where irrigation systems are established. Even in the more or less flat lands, there is little opportunity for infiltration of water and its storage in water tables for man's use. Soils, for the great part volcanic, are generally very thin. The Meseta Central, where populations are most concentrated and where, as a result, soils are required to produce greater yields, possesses agricultural land of a ridiculous thickness, which rests on more or less compact volcanic tufa, known locally as *tepetate* or hardpan; this, because of its lack of permeability, reduces the possibililties of stable upper horizons.

At the end of the Pleistocene Age a growing tendency was noted in Mexico toward conditions of greater aridity and, therefore, of invasion by the steepe and the desert. In the extensive desert and semi-desert areas of the north and northwest, with their deficient rainfall the year round and excessive evaporation, where it may be truthfully said that "it rains upward," the action of weather and wind on the soil is extremely intense.

The economic situation of the great mass of people, and their customs that derive from the condition of the soil's productivity, together with the constant need for corn, beans and chili, basic to their diet, also contribute to the threat of land destruction. To the above should be added the influence of the minifundio system of land tenure; here it is impossible to implant soil conservation programs or adopt measures conducive to halting the progress of land destruction. It is therefore easy to understand the difficult task of conserving Mexico's soil and water, especially when erosion has the advantage of centuries, and its damage is great.

Gravity and Extent of the Sickness

Many regions in the country are now completely exhausted and have had to be abandoned. It is not just today, but rather since pre-Cortés times, that the need has been felt—at present accentuated—for resettlement of populations. The decadence of the cultures of Yucatán, Tula, Teotihuacán, etc., relates the transcendental importance of these problems. Undoubtedly one of the regions in the country that has suffered the most destruction is in the State of Tlaxcala where *tepetate* crops out over vast areas. Furthermore, the crumbling of the volcanic structure of La Malintzin causes great masses of sand to wash down the slopes, making useless extensive areas of agricultural land. Technicians say that if this situation is not corrected, in less than fifty years people will not be able to find means of subsistence and, because of the complete destruction of the soil, will be forced to migrate to other regions. The same thing is happening in the State of Puebla, southeast of the abovementioned volcano and on the hills of Amozac, San Hipólito and Acatzingo. In the Federal District, a short distance from the capital, badly eroded areas afford excellent examples of the destruction of agricultural and forest land. In the greater part of the mountains surrounding Mexico City, formerly covered with cedars and pines, logging was so wanton that until a few years ago they were absolutely bare. The Lake Texcoco watershed, wooded in other times, was completely deforested and today one sees only hills stripped of vegetation and badly eroded, where rains wash away the soil to deposit it as silt in the lake's basin. Soils in the State of Morelos are so very poor as a result of erosion that farmers are forced to cultivate *tepetate* with consequent skimpy harvests. Here the valley of Villa de Ayala offers one of the most typical cases since, because of monoculture and inadequate agricultural practices, these lands, once of magnificent thickness, are today gouged by innumerable gullies, with a loss of eighty centimeters of soil in less than ten years.

The State of Oaxaca, like Tlaxcala, reveals one of the gloomiest panoramas of all, to the extent of being totally eroded with the exception of the purely tropical region. Farmers cling to the tiny strips of land remaining between gullies. The Ixmiquilpan zone in Hidalgo has such poor land that it is rightfully called the Valley of Misery. In Michoacán the whole region around the city of Morelia is destroyed and, because of erosion produced by wanton deforestation, Lake Pátzcuaro is rapidly becoming filled with silt. In Tacámbaro, in the same state, there are regions where soils have lost sixty centimeters in thickness during the last several years. In Central Veracruz crops are grown on mountains where rains have washed away the soil and in many places bare rock is

jutting out; farmers are thus forced to move from place to place in order to obtain the minimum food necessary for survival. Across the way from Nogales, Veracruz, on the Barranca de la Carbonera is another typical case of soil destruction through deforestation, this time with disastrous results in the industrial region of Orizaba. Here, due to widespread erosion, rain has provoked a series of floods for the past several years that have caused great losses both materially and in human lives. Yucatán is one of the most classic examples of soil erosion caused by destruction of plant cover because of fire and corn culture. Such destruction put an end to the splendor and began the decadence of the Maya-Quiché Empire through the ruination of the great cultural centers of the Chichen-Itzá and Tikal.

The red soils that cover vast expanses of the States of Aguas-Calientes, Zacatecas, San Luis Potosí and Jalisco are easily erodable, and poor agricultural practices increase erosion. Because these are the most densely populated areas in Mexico, the situation is more serious in this part of the country. Even in irrigated districts, deforestation of watersheds, poor use of water resources in irrigation operations, and wind erosion on the land near the arid hillsides have caused such great destruction that the lands have deteriorated in classification, through sheet erosion, to the extent that soil originally of Class I has had to be reclassified as Class III. The above are only a few striking examples that could be greatly multiplied if space permitted.

Abuse of native vegetation has run parallel to that of soil and water. The axe of destruction in the forest opened the way to the plow, thus placing the topsoil in a position to be carried away easily by wind or water. Overgrazing, by destroying the protective plant cover of the soil, has brought the same results. In agricultural regions we have already seen that continued use of the land down through the centuries, through improper techniques that were often self-defeating, has practically destroyed the productivity of the soil. There now remain only those regions that had been shunned by man because of their inaccessibility, but whose conquest and occupation has now been started. Among these are the Papaloapan Basin, the coastal plain of the States of Sonora and Sinaloa, the hot regions of Michoacán and Guerrero, the lowlands of Chiapas and Tabasco. It is encouraging to see that rational exploitation of these lands is being effected in accordance with well laid out plans.

Water Resources and Their Use

The average annual volume of rainfall in the Republic of Mexico is 1,518,896 cubic meters. Preliminary studies estimate the average annual runoff at 276,183,000 cubic meters, giving the rate of mean annual runoff as 0.813.

Figure 3. A reforestation scene near Mexico City. Plans called for the production of more than 100,000,000 trees in 1948.

However, owing to the unequal distribution of runoff in the different watersheds, this overall figure does not show the real picture. The rate of runoff for the waters flowing into the Atlantic is 0.122; that for the waters flowing into the Pacific is 0.056 and for waters in the interior only 0.004.

It is impossible to make adequate use of Mexico's water resources simply because of their irregular distribution throughout the various sections of the Republic. In fact, we find abundant water in regions where it is not needed and, on the other hand, scarcity in the areas where it is most needed. The gross amount of water available for irrigation purposes has been estimated at a little more than 62,000,000 cubic meters which, deducting fifteen per cent for loss in conduction, evaporation, etc., leaves a net volume of 53,000,000 cubic meters of available water which, considering the accepted average consumption of Mexico (10,000 cubic meters per hectare annually) would serve to irrigate somewhat more than 5,250,000 hectares.

Hydroelectric possibilities in Mexico have not been studied in detail because profiles of numerous important river basins are not available. However, we do know that besides river streams now being used to supply electric power there are rivers on the Pacific slope (States of Sinaloa, Nayarit, Michoacán, Oaxaca and Chiapas) and on the Atlantic (States of Puebla and Veracruz) that carry considerable volumes of water during the summer season and, therefore, make possible extensive hydroelectric resources.

The importance of water to the Mexican people, especially in the vast arid regions cannot, of course, be exaggerated; however, the influence of this element is of like primary importance over the entire country. We have only to consider Mexico's high death rate and, as part of it, the astounding figure for infant mortality, due primarily to diseases caused by polluted water. In few countries does there exist, as in Mexico, the imperative need for supplying pure drinking water to such great sections of the population who are now obtaining it under such deplorable conditions. There are many towns and villages whose inhabitants go directly to rivers to secure the water they need for nourishment and for domestic purposes. The prevalence of intestinal diseases and the resulting deaths speak eloquently of the conditions under which this water is used. Streams that do not fulfill minimum sanitary conditions should be condemned for consumption. Nevertheless, forced in many cases by dire necessity, numerous Mexican towns are obliged to resort to such supply.

Considering the importance of drinking water, its hygienic conditions are even more so. It is astonishing to note the frequency with which intestinal diseases occur in Mexico, either caused or transmitted by water or, in some way having something to do with the water consumed to satisfy human needs or that sprinkled on fruits and vegetables through irrigation. It is surprising to see how little is done, either officially or privately, to follow the most elemental regulations preventing contamination of water by excrement from population centers or by sewage dumped into large rivers by industries which, without the slightest consideration, appear to be unaware of the fact that other persons downstream must use these waters to supply their needs.

In the southern part of the country and especially on the slpoes of the three Sierra Madre ranges, toward the coast, the dry season considerably reduces the volume of streams to the extent that they either form puddles or cease flowing entirely. This, given other favorable environmental conditions, encourages the development of abundant larvae of the anopheles type which transmit malaria. Most of the modern means of communication, in particular highways, likewise contribute to the spread of malaria. Instead of getting rid of the gullies where water accumulates during the rainy season, deep ditches are opened on both sides of the new highways, thus increasing an environment favorable to the development of mosquitoes.

Restoration of Forest Wealth

In the archives of the *Dirección Forestal y de Caza* of Mexico are numerous reports on various forest areas of the country, some of which have been published. However, this great volume of important data has not yet been compiled into one study covering the whole Republic to present in sufficient detail a complete picture of existing forests, their characteristics and distribution. In 1937 Mr. J. García Martínez carried out an intensive study along these lines which includes a map of the "Forest Zones of the Republic," bounded according to the various altitudes above sea level, as shown in the following table:

Forest Areas of the Republic According to Altitudes Above Sea Level

Altitude above sea level	Total area of land in country at various altitudes	Percentage of total area of land at various altitudes in relation to area of country	Surface area covered with forest vegetation	Percentage of forest area in relation to total area of country
	Hectares	Per cent	Hectares	Per cent
Totals:	196,936,500	100.00	28,471,138	14.45
0-500	64,730,100	32.86	16,974,041	8.62
501-1000	32,688,600	16.60	4,249,417	2.16
1001-1500	40,560,200	20.60	2,636,412	1.34
1501-2000	38,811,000	19.71	3,104,880	1.57
2001-2500	18,910,800	9.61	1,134,648	0.57
2501-3000 or more	1,235,400	0.62	371,740	0.19

According to the table, only 28,500,000 hectares or 14.5 per cent of the total surface area of Mexico is covered by forest vegetation. Approximately 5,000,000 hectares are in still unexploited tropical rain forests and remote mountain forests.

The need for a detailed inventory of forests moved the Ministry of Agriculture to undertake toward the end of 1947 accurate inventories, estimating that this census could be finished within a period of two years. Up to that date, concessions had been granted without knowledge of available reserves. Fortunately, this policy of "liberality" seems to be over, and even in 1947 the Ministry of Agriculture granted only 25 per cent of the area authorized in previous years. On the other hand, the severe summer season of 1947-48, so merciless on Mexico's soil, forced the Ministry of Agriculture to issue emergency permits for the manufacture of charcoal. As is well known, the processing of wood charcoal has played an important role in forest destruction especially around population centers. This explains the deplorable condition of forests in the States of México and Puebla, of Michoacán and Jalisco, where cutting for firewood has been carried on extensively. Forestry conditions in the Federal District are the most serious; this has resulted in established reglementation on restoration and reforestation, which could no longer be avoided. At the same time, federal protection zones have been established in various watersheds. In 1947 some 25,000,000 young trees of various species were produced in different nurseries; this year they will be planted in an effort to compensate for part of the deforestation suffered. The plan this year is to produce more than 100,000,000 trees in the nurseries.

The new Forestry Law, decreed January 10, 1948, is in force and promises to change Mexico's forestry outlook inasmuch as, without overlooking forest exploitation through planned forest management, it deems the conservation and development of forests extremely urgent. Under the new law, a National Forestry Commission is created and Industrial Forests Exploitation Units established on public or private forests to supply the raw materials required by industry. It is understood that industrial development must, for the good of the nation, take precedence over private interests. On the other hand the *Dirección Forestal* has organized 3,000 Defense Corporations including 75,000 workers who, with scant funds, cooperate effectively in the extinction of fires. The Air Forces have recently begun to be used in locating fires.

Protection of Fauna and Flora

It is disheartening to see the lack of attention paid in Mexico to the preservation of wildlife, especially when it concerns the many species that are eaten as food, and consequently, are vigorously hunted. In spite of vigorous efforts, to date the work undertaken by the Mexican National Section of the International Committee for Bird Preservation has not reached the attention of the public. The distribution of the ancient Indian civilizations throughout national territory has made difficult, except in inaccessible areas such as high mountain chains, the preservation of great expanses of land in its natural condition. From time immemorial the Indians have devoted themselves to hunting and, since the Conquest, to the development of the cattle industry. Destructive overgrazing has caused the gradual deterioration of grasslands. The increasing number of goats, destroyer *par excellence* of vegetation, has produced the spreading not only of *brucelosis*, but has also caused in many places the destruction of the natural biological balance established throughout many centuries, as well as profound modifications of vegetation. The opening of new highways, making accessible zones never before inhabited, likewise contributes, as is happening with the Inter-American Highway, to the destruction of the virgin areas still remaining.

The development of the guano industry in the Mexican Islands off the west coast of Lower California has been possible by means of protective measures afforded these birds that produce such valuable fertilizer. International commitments on the part of Mexico as a signatory power of the Mexico-United States Convention for the Protection of Migratory Birds and Game are fulfilled as well as an inadequate staff and deficient communications permit.

During the presidency of General Lázaro Cárdenas numerous national parks were established in Mexico. The principal promoter of this new policy was don Miguel de Quevedo, known as the "Apostle of the Tree." Through excellent protective measures forests, natural sites and incomparable scenic beauty have been saved from destruction.

Conservation Program

Mexico's program of conservation of natural resources is being carried out in accordance with planned activities: programs of water resource use, controlled forest exploitation, protection of fauna and flora, reforestation, and, above all, activities regulated by the "Law of Soil and Water Conservation" published in the *Diario Oficial* (Official Government Bulletin) of March, 1946.

The law declares to be for public benefit:

1. Research and studies relative to the classification of land and water resources and to the most adequate methods and practices for the conservation thereof.

2. The adoption of all measures conducive to the conservation of the country's land and water resources; to the prevention and control of erosion; to the control

of floods; to the prevention of damage to reservoirs and watersheds, etc.

3. The dissemination and propagation of technological information and practices relative to better land and water use and agricultural resources.

4. The develpoment of a permanent educational program concerning conservation principles and practices that will include the entire population, from the nation's youth and the farmers on up.

5. The establishment of Soil Conservation Districts.

The Ministry of Agriculture, through its Division of Soil Conservation, has now begun soil conservation practices on the land that will guarantee its conservation. This technical knowledge reaches the farmers through the assistance afforded by the staff and personnel of the Division to the farmers organized into Soil Conservation Districts. Since the beginning of 1948 a class on the Techniques of Conservation has been established in the National School of Biological Sciences of the National Polytechnical Institute of Mexico, as a part of the biologists' course. The creation of new specialists within such a renowned institution as this will undoubtedly contribute greatly to the dissemination of such knowledge.

The general landscape of Mexico will change with the introduction of this new form of land use which includes: crop rotation, use of green fertilizer, strip cropping around slopes, contour plowing to prevent erosion, construction of drainage terraces to carry off excessive rainfall, planned land use, employment of soil improvers and fertilizers, control of floods by systems of dams, etc.

Mexico is faced with the urgent necessity of stabilizing her agricultural production in order to rid herself of the periodic food scarcities and even hunger that unfortunately have devastated the country in the past and thus avoid the huge sums spent to import supplementary basic foods. Furthermore, increased crop yields will contribute greatly to better social and economic conditions of the farming class on whom the future of the country fundamentally depends.

The interest awakened by these new agricultural teachings and conservation practices is equal only to the problem we have to face. The first steps on firm ground have been taken. With intelligence and hard work we shall learn how to use our natural resources and conserve and increase the production capacity of our soil.

BIBLIOGRAPHY

Atwood, W. W. 1941. La Protección a la Naturaleza en las Américas. *Instituto Panamericano de Geografía e Historia,* Pub. No. 57, pp. 1-99.

Beltran, E. 1941. Los Recoursos Naturales de México. *Biblioteca Enciclopédica Popular, Secretaría de Educación Pública,* No. 106.

Galicia, D. F. 1941. Mexico's National Parks, pp. 107-110 in "Shelford's List of Reserves that may serve as Nature Sanctuaries of National and International Importance, in Canada, the United States, and Mexico." *Ecology,* Vol. 22, No. 1, pp. 100-110.

Garcia Martinez, J. 1937. Las Superficies Forestales de la República. *Boletín del Departamento Forestal y de Caza y Pesca.* Vol. 3, No. 8, pp. 127-140.

Garcia Quintero, A. 1941. Los Efectos de la Deforestación en el Régimen de los Ríos. *Irrigación en México,* Vol. 22, No. 5, pp. 339-347.

Garcia Quintero, A. 1943. Recursos Hidráulicos Superficiales de la República Mexicana. *Irrigación en México,* Vol. 24, No. 5, pp. 5-23.

Garcia Quintero, A. y Benassini, O. 1941. Hidrología de la República Mexicana. I. Escurrimiento Medio Anual. *Irrigación en México,* Vol. 22, No. 2, pp. 87-95.

Garcia Quintero, A. y Benassini, O. 1942. Hidrología de la República Mexicana. II. Gastos Máximos Instantáneos. *Irrigación en México,* Vol. 23, No. 6, pp. 5-14.

Gomez, M. R. 1945. Tendencias, Medios y Fines de la Política Agrícola de México. *Irrigación en México,* Vol. 26, No. 2, pp. 5-29.

Leopold, A. 1946. La Etica de la Conservación. *La Conservación en las Américas,* No. 1, pp. 4-19.

Meyer, H. A. 1941. Forestry in Mexico. *Chronica Botanica,* Vol. 6, Nos. 17-18, pp. 395-399.

Nelson, E. W. and E. A. Goldman. Art. Mexico in "Shelford, V. E. *ét. al.* Naturalist's Guide to the Americas," pp. 574-596.

Orive Alba, A. 1946. Limitaciones del Porvenir agrícola en México. *Revista Industrial,* Vol. 1, No. 1, pp. 103-105 y 121-122.

Orive Alba, A. 1946. La Política de Irrigación. *Problemas Económico-Agrícolas de México,* pp. 101-142.

Osorio Tafall, B. F. 1946. Anotaciones sobre Algunos Aspectos de la Hidrología Mexicana. *Revista de la Sociedad Mexicana de Historia Natural,* Vol. 7, Nos. 1-4, pp. 139-165.

Osorio Tafall, B. F. 1948. Aumentemos la Capacidad Productiva de Nuestros Suelos. *Técnica,* No. 2, pp. III-V.

Patiño, L. R. 1943. La Importancia de la Conservación del Suelo. *Irrigación en México.* Vol. 24, No. 6, pp. 5-22.

Patiño, L. R. 1944. Instrucciones provisionales sobre la forme de como hacer un levantamiento de Conservación del Suelo. *Irrigación en México.* Vol. 25, No. 3, pp. 22-52.

Quevedo, M. A. de 1939. Anteproyecto de Plan Sexenal para el Periodo 1941-46 en los Ramos Forestal y de Caza y Pesca. *Boletín del Departamento Forestal y de Caza y Pesca,* Vol. 4, No. 14, pp. 1-18.

Shelford, V. E. 1941. The Nature Sanctuary Idea. *Audubon Magazine,* pp. 503-510.

Tamayo, J. L. 1946. Datos para la Hidrología de la República Mexicana. *Instituto Panamericano de Geografía e Historia,* Pub. 84, 448 pp.

Vogt, W. 1945. Hunger at the Peace Table. *Bulletin Audubon Society New Hampshire,* Vol. 16, No. 2, pp. 47-46.

Vogt, W. 1946. Los Recursos Naturales de México. Su Pasado, Presente y Futuro. *Memorias del II Congreso Mexicano de Ciencias Sociales.* Vol. 2, pp. 5-102.

Soils Can Support More People

With the information now available, I feel confident that we can feed at least 50 per cent more people in this country than we are now supporting and I have every reason for thinking that, by the time we reach a population of 220,000,000, our agriculture shall have progressed enough to enable us to carry at least double our present population without any sacrifice in our standard of living and without any depletion of the productive capacity of our soils. I feel confident that such a goal is agronomically feasible. Whether or not it is actually achieved will depend largely upon social, economic and political developments.—RICHARD BRADFIELD, *before the Academy of Political Science, November 10, 1948.*

Minor Elements as Missing Links

FIRMAN E. BEAR

Dr. Firman E. Bear is Head of the Soils Department, Rutgers University, New Brunswick, New Jersey. He is also a member of the Editorial Board of the JOURNAL and Editor of *Soil Science*. Dr. Bear is a frequent contributor to the JOURNAL.

SEVERAL YEARS AGO a prominent truck farmer brought some horseradish roots into my office with the complaint that the sauce which was being produced from them was full of black specks that made it unattractive to the trade. On cutting the roots crosswise, we found that each of them contained a ring of black tissue, about half way between the surface and the center.

Fortunately, we had just completed a careful study of the boron needs of New Jersey soils and, as a result, had learned to distinguish the symptoms of deficiency of this element on a considerable variety of crop plants. Although we had seen nothing exactly like the markings in the horseradish roots, our best guess was that a lack of boron was the cause of the trouble. When the farmer, following our suggestion, applied borax at the rate of 20 pounds per acre, the black rings were eliminated.

Early last year another farmer called our attention to the very poor growth of alfalfa on part of his farm, and asked for help. Samples of both soil and alfalfa were brought into the laboratory for examination, but nothing in the chemist's report provided any very definite clue, except that the pH value of the soil averaged about 7. This suggested that possibly the availability of soil manganese had been lowered too far by such heavy liming, and that a lack of this element was the limiting factor. An application of manganese sulfate, at the rate of 50 pounds per acre, brought immediate response. The pale yellow color between the leaf veins soon disappeared, and an 87 per cent increase in yield was effected on the crop that was harvested a few weeks later.

The case for manganese is especially interesting because, at low pH levels, so much of this element is often present in available form in soils as to be toxic to many crop plants. At high pH levels, however, the availability of manganese may be so lowered that its lack becomes the limiting factor in plant growth, as was the case with the farmer's alfalfa.

Molybdenum Now Being Studied

A few months ago our attention was called to some troubles that were being experienced by a dairyman in the southern part of the state. He had been forced out of business by the loss of a large number of cows and calves that suffered from some disease that baffled our state veterinarian. At his request, and in the hope of being of some help, our department collected samples of soils and plants from that farm for laboratory study. Here, again, nothing of any special importance was noted except that the pH value of the soil was just a little below the neutral point.

It happened that we were making a preliminary study of molybdenum as a necessary nutrient element for alfalfa. Molybdenum appears to be essential to the well-being of the microbes that live in the nodules on the roots of this and other legume plants. Cases of deficiency of this element have been reported from a number of areas. On the other hand, if this element is present in such amounts in the soil as to permit of the plant's accumulating 10 parts or more of it per million of dry matter, this may prove poisonous to the consuming livestock.

It is known that the availability of the molybdenum in acid soils is increased by liming. Since the soil on this farm had been very liberally limed, it seemed possible that the pasture plants contained too much of it. Examination of the several types of plants showed that whereas we would normally expect around one part molybdenum per million of dry matter, some of the red clover from this farm contained nine parts per million. As a result, this element is now under suspicion as the possible cause of the trouble, and a considerable amount of work is being undertaken to test this possibility.

During World War II, a number of farmers who are located in the direction of the movement of the prevailing winds with respect to certain industrial plants, complained of fume damage to their crops. These factories were manufacturing chemicals for warfare purposes. The evidence that damage was being done was quite conclusive and, ultimately, fluorine came under scrutiny as possibly being responsible for the trouble.

In due time, the fumes were brought under control, but the question remained as to the effect of the fluorine that had accumulated in the soil on the well-being of crops. Greenhouse and laboratory studies soon demonstrated that if the pH value of these naturally acid soils was raised to about 6.5, the availability of the fluorine was so reduced that very little of it was absorbed by

plant roots. By the supplemental use of superphosphate, the solubility of the soil fluorine was further lowered, and all damage was eliminated.

Magnesium is a Limiting Factor

Several years ago, a sweet potato grower noted that the older leaves of his plants had turned yellow, except for the veins, which remained dark green. Thinking that possibly the fertilizer had leached out of his sandy sooil, he applied an extra dose of a high-potassium fertilizer. Instead of effecting the expected improvement, the fertilizer caused the plants to look much worse.

On a nearby farm, a load of poultry manure had been scattered irregularly over a sweet potato field. As a result, the leaves of the vines over the treated area turned dark green, whereas those on the plants that covered the remainder of the field were bright yellow. Fortunately, a year earlier, a series of plots had been set up in one corner of this field to test for possible minor-element deficiencies. The plot treatments showed that the limiting factor was a lack of magnesium. The extra potassium, which the one farmer had applied, had tended to crowd out even the small amount of magnesium in the plants. The poultry manure, which the other farmer had used, was relatively low in potassium and high in magnesium. It is important to remember that poultry are fed grain rather than hay, and that magnesium tends to concentrate in the seed of plants.

Recently we have had some very remarkable increases in well-being and yield of beets and spinach as a result of an application of nitrate of soda when used in comparison with ammonium nitrate and nitrate of lime. The effects were apparent immediately after the seed had germinated, and they continued throughout the crop season. The final yields of sugar beets were twice as high with nitrate of soda as with ammonium nitrate.

This points to the importance of sodium, either as a direct nutrient to plants or as a partial substitute for potassium. In the soil referred to, the amount of available potassium was small. It was evident, however, that the nitrate of soda had a much greater effect than the other carriers of nitrogen, and that this must be credited to its sodium.

Mineral Content of Vegetables Studied

About a year ago, the *Reader's Digest* asked us to study the mineral content of vegetables from various parts of the United States. As a result, some 200 samples of snapbeans, cabbage, tomatoes, and spinach were collected and analyzed for two elements. These came from commercial fields in Georgia, South Carolina, Virginia, Maryland, New Jersey, New York (Long Island), Ohio, Indiana, Illinois, and Colorado. The soils of these states represent the badly leached coastal plain areas of the south and east, the more nearly neutral areas of the north-central region, and the alkaline irrigated areas of the west.

The analysis of these vegetables showed that the total mineral content increased from south to north and from east to west. This was especially true of such elements as calcium and potassium, but it also applied to most of the minor-nutrient elements, such as boron, copper, cobalt, and molybdenum. The percentages of manganese and sodium, however, decreased from east to west and that of zinc from south to north.

One of the practical conclusions which might be

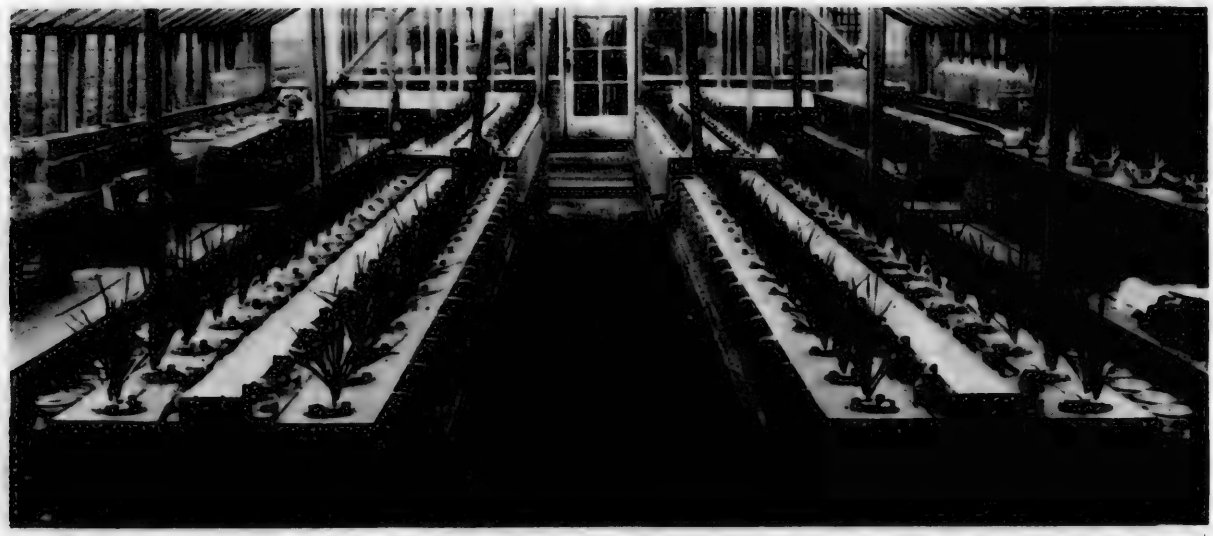


Figure 1. Solution-culture studies of manganese with oats.

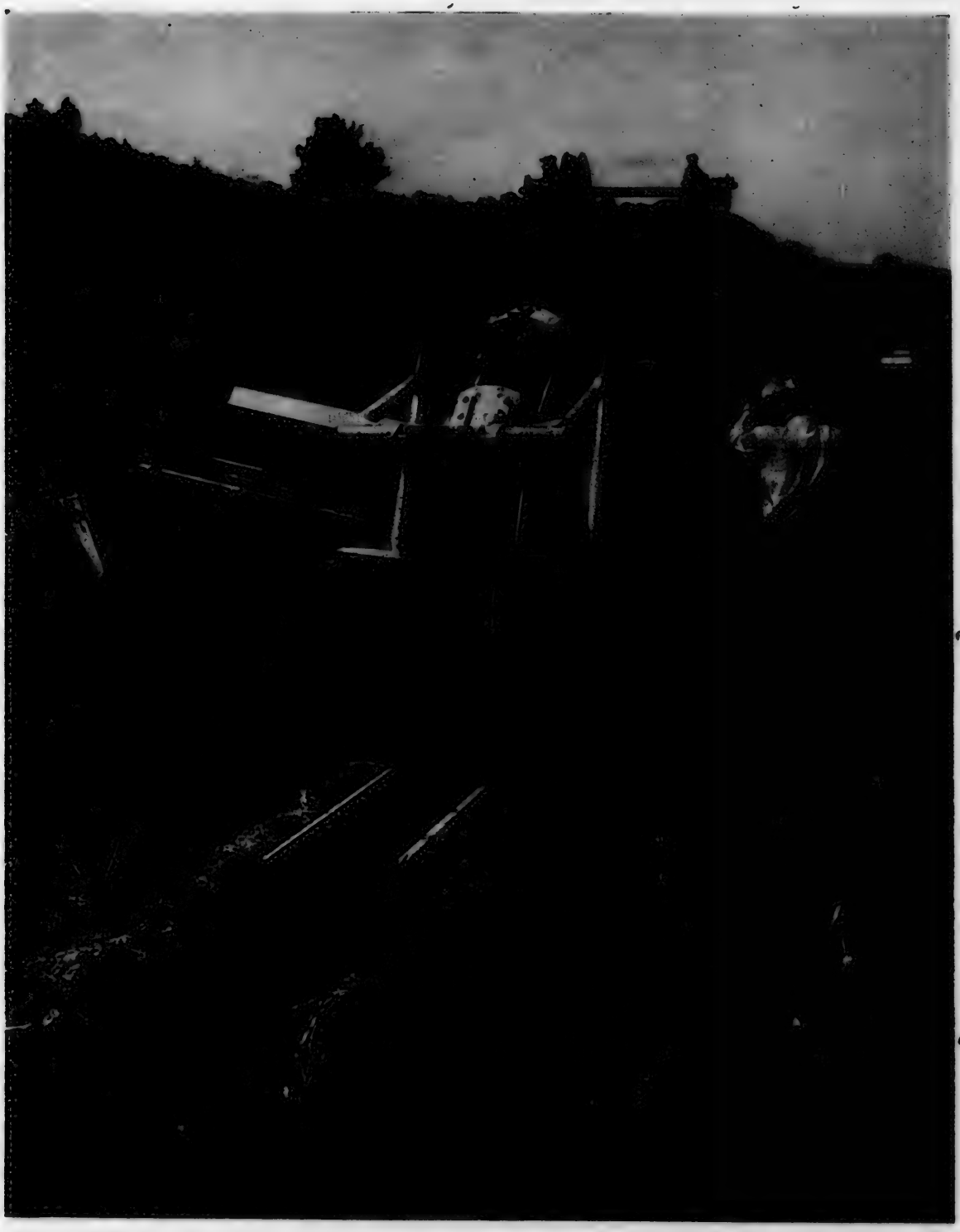


Photo by Hermann Postlethwaite, SCS

There are many poorly drained areas on farms that often bring about the improper use of other lands. This ditching machine is owned by the State Soil Conservation Committee of West Virginia and is loaned to soil conservation districts for work on cooperating farms to correct drainage problems.

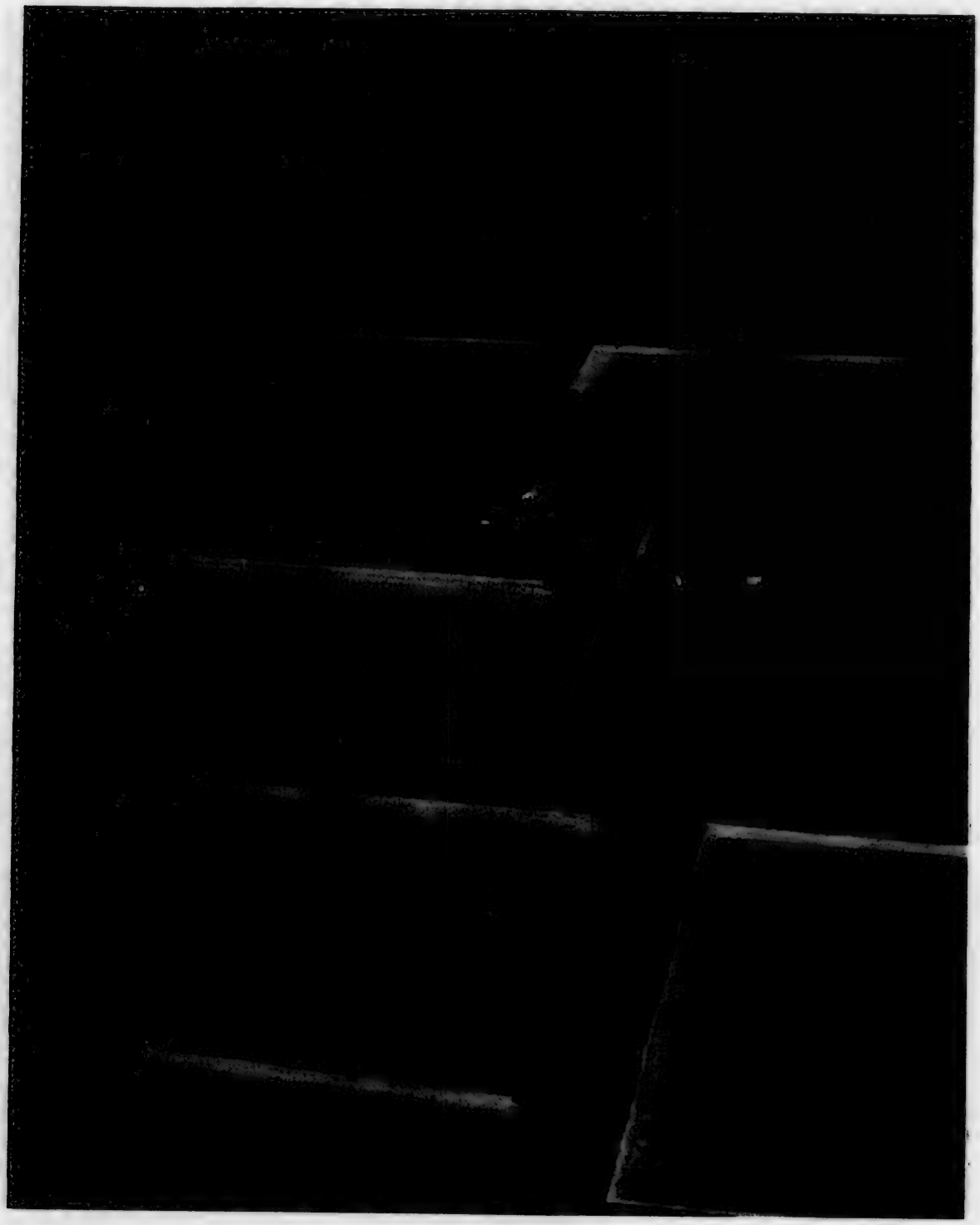


Photo by Hermann Postlethwaite, SCS

Windbreaks serve to protect farm buildings against severe winds. They also help to keep the soil anchored. This aerial view of a windbreak was taken on a ranch near Vernon, Texas. The trees were planted in 1939 under the supervision of the United States Forest Service.

Photo by Hermann Postlethwaite, SCS

This landscape view shows parts of five farms in the Spoon Creek Watershed near Coshocton, Ohio. Farmers and ranchers throughout the country are learning that watershed management is the next big step in the conservation movement.

Photo by Hermann Postlethwaite, SCS

Irrigation farming requires the land to be leveled in order that the water may be used properly and efficiently. The leveling equipment used in this Oklahoma scene is in the Altus-Lugert Irrigation District.

Figure 2. Sandy coastal-plain soils usually require minor elements in addition to NPK.

drawn from these vegetable analyses, as they apply to the needs of man, is that it is fortunate that the several foods which we consume come from such widely separated areas. Thus the deficiencies of one area and the possible excesses of another tend to balance each other. It suggests that the city dweller may be better nourished as to mineral elements than the farmer's family, whose food is more largely the produce of a particular farm and soil. It makes it even more apparent that livestock that consumes feed which is derived entirely from one farm is more likely to suffer from mineral deficiencies or excesses than is the average man. The same applies to any plant life that is the product of a given soil to which supplemental fertility has not been added by way of manure produced from imported feedstuffs.

We now know that large acreages of land in New Jersey, as well as in other states, are deficient in one or another or several of the minor nutrient elements. Thus it is now common practice to add five pounds of borax to each ton of fertilizer in some areas, and 25 pounds is often applied per acre for alfalfa. This will often increase the yield as much as a ton per acre. Similarly, it has been found advisable to add 40 pounds of available magnesium per acre for most of the crops that are grown on the coastal plain area. Marked increases in yield of potatoes, sweet potatoes, cotton, and tobacco have resulted from such additions to the regular NPK fertilizer.

It is now standard practice to add 50 pounds of manganese sulfate per acre to soils that have been overlimed. This is especially effective in the market-gardening areas where overliming is quite common. It also applies to certain parts of the high-rainfall areas where the soils are naturally rich in calcium carbonate, such, for example, as the Homestead area in Florida. Vegetable growers who farm peat soils also apply up to 50 pounds of copper sulfate per acre with great benefit to their crops. Both of these sulfates, and zinc sulfate as well, are being used on Florida citrus to good effect, sometimes by way of the soil and at other times in spray form applied directly to the trees.

More Minor-Element Deficiencies Likely to Occur

One of the most interesting recent developments in the field of minor elements has been the discovery in the southern states that, as corn yields are pushed ever higher by the use of larger amounts of nitrogen, the incidence of white bud, a sign of zinc deficiency, is increasing. The same tendency toward an increase in deficiencies of the other minor elements can be expected as the yields are raised by breeding, selection, liming the land, and making greater use of NPK fertilizers.

In such countries as India, where practically no fertilizer is used, acre yields are determined largely by the capacity of the soil to continue to yield up small amounts of all the essential mineral elements. Under such conditions, minor-element deficiencies are less likely to develop than they are in areas where acre yields are maintained at high levels by the use of mineral fertilizers.

The very good effects normally obtained from composts can partly be explained by the fact that they carry small amounts of minor elements in readily available forms. It happens also that most back-yard composts, as well as most animal manures, are the product of more than one soil. Thus the refuse of fruits and vegetables from a wide variety of origins finds its way into the

(Continued on page 76)

Conservation Education In The Schools

R. H. ECKELBERRY and CARL S. JOHNSON

Conservation education cannot be done well by individual teachers because it cuts across many areas of living and learning. It is a job for the entire staff. The authors of this paper suggest certain principles and criteria for the development by each school of a program appropriate to its own situation. Such a program must deal with all the major problems—life, health, citizenship, family living, conservation and others.

IN THIS DISCUSSION we shall deal with three principal topics: (1) the present status of conservation education in the schools; (2) a program for the future; and (3) what lay citizens can do about it.

On the level of leadership and promotion, much has been, and is being done. Many governmental agencies, such as the Soil Conservation Service, the Forest Service, the federal Fish and Wildlife Service, state departments of conservation, and agricultural extension services have prepared materials and actively promoted education in this field. Likewise, a large number of private conservation organizations, such as the Soil Conservation Society of America, the American Forestry Association, the National Wildlife Federation, the Izaak Walton League, and Friends of the Land are doing effective work. Indices of the growth of interest in, and concern about, conservation are provided by the activities of many chambers of commerce, Federal Reserve Banks, industrial concerns, railroads, service clubs, and other agencies Further evidence of the increasing public concern is provided by the wide acceptance of such books as Vogt's *Road to Survival,* and Osborn's *Our Plundered Planet.* The Association for Supervision and Curriculum Development of the National Education Association has recently published a yearbook (*Large Was Our Bounty*) in this field and the American Association of School Administrators is preparing another one. The daily press, advertisers, the radio, and even Hollywood are giving increased attention to problems of resource use. Many textbooks have been revised so as to give some attention to problems in this field. Recently the first Inter-American Conference on Conservation of Renewable Natural Resources was held, and a world conference is scheduled for 1949. The establishment of the National Committee on Policies in Conservation Education and of the Conservation Foundation provides further evidence of a growing concern which is bound to affect school work.

A Job for the Entire School Staff

When we come to the actual work of the elementary and secondary schools the picture is less good. Many individual teachers are doing a good job in teaching certain aspects of conservation and many more are honestly trying to do so but are handicapped by inadequate knowledge and skill. These teachers, however, are but a small minority of all the teachers in the country. Moreover, their methods are usually less effective than they should be because of failure to utilize direct field study and to make proper use of the educational resources in the community.

Individual teachers, no matter how good, can not adequately deal with the problem of conservation education. Conservation cuts across so many areas of living and learning that it can be adequately treated only when a school organizes its entire program with reference to conservation as a major theme and objective. In other words, conservation should be a job for the entire school staff. Very few schools have attacked the problem in this way. Until school programs are organized in this way, the following generalization from the *Yearbook* (1) previously mentioned will continue to be valid:

> *In general, schools seem to have directed activity on resources toward providing information on spe-*

"*Conservation Education in the Schools*" was presented as a Discussion at the 1948 Annual Meeting of the Society held in Cincinnati last December. R. H. Eckelberry is in the Bureau of Education Research, College of Education, Ohio State University, Columbus, Ohio. He is an ardent conservationist and teaches at the Ohio Conservation School during the summer months.

Carl S. Johnson is a graduate student at Ohio State University and is working towards a doctor's degree in conservation.

cific resources of one sort or another, rather than toward understanding of the balance of the natural environment or of the many controlling inter-relationships under which the environment operates.

Among the major reasons for the failure are: the large number of poor teachers, ill-informed administrators and supervisors, public apathy and indifference (which is decreasing, as we have indicated in a preceding paragraph), opposition to change on the part of both school people and laymen, departmentalization and the resultant emphasis on traditionally organized bodies of subject-matter, and "passing the buck" to the science teacher instead of recognizing that conservation education is the responsibility of the entire staff.

There is little hope that most teachers now being trained will be substantially better prepared with respect to conservation than those now in service. College programs are characterized by emphasis on subject-matter organized traditionally rather than functionally. Teacher-training programs give relatively too much attention to methods and professional courses and too little to the development of adequate knowledge related to problems of living: health, family life, citizenship, conservation, etc. Too often the academic training of teachers, especially secondary teachers, is too narrowly specialized. There is little training in field work because college staffs lack such training themselves. The work of teacher-training institutions, like that of the schools, illustrates the fact that educational institutions have usually followed rather than led public opinion in meeting new needs.

We are unwilling to close the discussion of the present status of conservation without pointing out that there are many promising recent developments. These include: conservation workshops, which have increased from one in 1939 to more than one hundred in 1948; elective conservation courses in colleges, in which enrollments are increasing; conservation curricula in a few colleges; field-experience programs in some teacher training institutions; the employment of conservation-education leaders by state departments of education or conservation; forward-looking curriculum revision by some schools and school systems; and a substantial improvement in the quality of persons entering the teaching profession.

A Program for the Future

We shall not attempt to furnish a blueprint for a desirable school program in conservation education. We believe that there is no *one* best way in which all schools should work toward the objectives of good conservation education; each school should develop a program appropriate to its own situation. We can, however, suggest certain principles and criteria which can serve as guides toward better school work in this area.

Conservation can be well taught only in a program that deals effectively with all the major problems of life —health, citizenship, family living, conservation, etc. Generally speaking, those programs are best where the school:

1. Is fully cognizant of the needs of individuals and society in its community and bases its program squarely upon these needs.
2. Gives priority to the needs of society when these are in conflict with individual needs.
3. Continually re-examines its program in the light of new conditions and new needs.
4. Develops in its pupils self-reliance and competence in solving problems of living rather than merely imparting information.
5. Provides much first-hand experience for its pupils.
6. Makes good use of the learning resources available in its community.
7. Seeks to relate adult education closely with that of young people.
8. Emphasizes throughout its program the dependence of man upon resources, the inter-relationship of resources, and the inter-dependence of men.

How can schools make progress toward the goal indicated by these criteria? We should not expect a revolutionary change in school programs; we should expect that the process will be evolutionary. A school should not fail to take desirable next steps just because it cannot wipe the slate clean and start all over again with a better program.

Integration, that is the insertion of certain desired teachings into the present courses, is often advocated as the method for getting conservation ideas into the school curriculum. It may be the best next step but it is only a step in the direction in which we believe schools should go.

Almost any school can, if it will, move in the direction indicated by the principles we have listed. State laws, regulations of state departments of education, college entrance requirements, and so on leave a very large measure of freedom to the local board of education and to the school staff. Within wide limits a community can have the kind of school it wants. We have largely forgotten that schools are our own and hence, in many cases, we as citizens have not done our part in making them better. We often forget that improvements in education and other aspects of living are practically always initiated by minorities. This principle, which is often overlooked when we teach democracy as the rule of the ma-

jority, is illustrated by the Soil Conservation District movement. Probably there has never been a Soil Conservation District established except through the work of a small group that led the way. The same thing is true with respect to the achievement of woman suffrage, the establishment of national parks, and many other developments. Christianity itself was once the faith of a very small minority. So in working for school improvement, citizens' groups should not be discouraged because they are minorities. If they have a good cause and if they are not weary in well-doing they can usually bring about acceptance by the majority.

What the Lay Citizen Can Do

As we have indicated in preceding paragraphs, lay citizens like yourselves can do much to promote school improvement. You have abundant opportunities. Some of you are school-board members, some are friends of school-board members, and all of you help elect school-board members. Many of you are parents of children in school and members of the Parent-Teacher Association. Some of you are church members and officials, some of you are active in service clubs and other civic organizations. Most of you belong to the "leadership core" in your communities. As individuals you probably could do relatively little to bring about school improvement. But you need not bear the burden of school improvement alone. By working through the organizations in which you are active you can do much.

How should you use your power? You should not, we think, bring pressure on school authorities to do specific things, hand out lists of objectives, or outline a program for the school. You should *work with* the school authorities in somewhat the same way as the Soil Conservation District board of supervisors works with the work-unit conservationist, and the conservationist works with the individual farmer. The strength of the Soil Conservation District lies largely in the give-and-take relationship of the expert and the layman. Sound school progress will come most rapidly when educators and lay citizens really co-operate in bringing it about.

What are some specific things that you can work for in your community? You can encourage some of your best young people to become teachers. You can work for more adequate salaries for teachers. You can do many other things to improve the status of teachers in your community: grant them the same freedom to live their own lives that other decent persons enjoy; ask them to speak on your programs; appoint them to committees in organizations to which you belong; grant them honorary memberships in your organizations for, say, a year; at least get acquainted with your teachers; better yet, invite them to dinner.

You can insist upon your teachers having adequate preparation before they are employed, and if you insist, you can eventually get the kind of teachers you want. In this, as in other areas, the market largely controls the product. You can help teachers improve their preparation by granting them scholarships to attend workshops. You can encourage and assist in the development of in-service programs for your school administrators and then for your teachers. You can encourage your schools to establish school forests or other outdoor laboratories and to hold field days. You can furnish and assist in the development of maps, guides, and other source materials which will help teachers get acquainted with, and use, the educational resources of the community. Any one of you who is a farm planner can invite a teacher to go along with you when you are working on a farm plan. You can help teachers evaluate the accuracy of conservation education materials and help schools secure valid materials.

These are some of the ways in which you can help your schools do a better job, including more effective conservation education. Because you are both citizens and conservationists, you have a two-fold obligation.

LITERATURE CITED

1. *Large Was Our Bounty: Natural Resources and the Schools.* 1948 Yearbook, Association for Supervision and Curriculum Development of the National Education Association, Washington, D. C., 1948, p. 70.

Elements as Missing Links

(*Continued on page* 73)

compost heap, and most dairy farmers bury large amounts of grain feed. It is not surprising, therefore, that composts and manures are highly effective, especially when they are used in very liberal amounts.

We are much better informed about what to do when certain well-known deficiency symptoms become apparent on crop plants than we are about why these elements are needed by plants and animals. In other words, it is important that a great deal of work be done to determine more exactly the functions in living things of a considerable number of needed minor elements, and the reasons for the toxicity of other elements that often cause trouble with plants and animals. Fortunately, a large amount of time and money are now being invested to the study of these elements. The research in this field should provide highly important clues to improved agricultural practices.

Professional Work of Soil Conservationists

J. G. STEELE

Soil conservation as a profession is strong because the concept has grown spontaneously in the minds and hearts of several thousand men. It is recognized in the Federal service, in agricultural colleges, industries, business and industrial concerns and elsewhere. Other professions embrace aspects of it in their work because of its broad relationship to all the sciences. Soil conservationists, because of this understanding on the part of society need to keep abreast with new professional techniques and changes at all times. In addition, the Soil Conservation Society of America should begin now to provide for a definite set of professional standards.

SOIL CONSERVATIONISTS have an opportunity and a duty unique in human history. We need to understand our profession if we are to carry out our duty. To do this we should examine from time to time the scientific background against which we work; the work that is done by professional soil conservationists and by others in this field; and the opportunities that exist for extending and strengthening our professional activities.

J. B. Lawes and J. H. Gilbert made history in agricultural science when they established the Rothamsted Experiment Station near London in 1843. They combined the resources of a business man and a scientist in productive research. In some respects they set a pattern for research in the science of agriculture. Later the Federal Government and the States in this country set a pattern for Government-sponsored agricultural research. Fundamental discoveries and useful applications came from numerous agricultural research centers supported mostly by public funds. In recent years, partly because of military needs, public support of some phases of scientific work has been greatly increased. A national science foundation has been proposed. The ever-increasing fund of scientific knowledge that has been developed with public aid furnishes the subject matter for several professions, including ours.

Public support of soil conservation work received great impetus when the Congress provided for investigations of soil erosion beginning in 1929; and again when the Soil Erosion Service was established in 1933. The organization thus created was re-named the Soil Conservation Service by legislation enacted in 1935. Hundreds and later thousands of professional soil conservationists were needed to carry out the work assigned. They did not exist ready-made, but had to be developed from men who already possessed the necessary scientific or technical training and experience. Now, a little more than 15 years later, soil conservationists are recognized by title or by duties not only in the Federal service, but in agricultural colleges, industries, public utilities, business concerns, and many other establishments. Anyone who is concerned with land management may need and profit from the services of a professional soil conservationist.

Soil Conservation Science Defined

The science of soil and water conservation embraces segments of many of the physical, biological, and social sciences. Whether we regard the subject as one branch of science or as a group of related sciences does not matter greatly for this purpose. Certain soil conservationists are engaged in research, which may be defined as the accumulation and arrangement of facts so as to draw new ideas out of them. Conant stated, "Science advances not by the accumulation of new facts (a process which may even conceivably retard scientific progress) but by the continuous development of new and fruitful concepts." (1) Other soil conservationists, far more numerous than those who do research, apply scientific principles in practical plans of land management to fit particular situations. They are the main group of professional soil conservationists. We might remind ourselves that a professional person, in this sense, is one who possesses special knowledge which he uses in instructing, guiding, or advising others, or serving them in some art. These professional workers do not carry on research as such. They may contribute to the science of soil and water conservation if they organize and put in writing new concepts and ideas that grow out of their observations and knowledge. We should know the functions of research and of professional practice, and the qualifications required for each.

Dr. J. G. Steele is Head of The Survey Analysis Section, Soil Conservation Service, with headquarters at Washington, D. C. He has written and published many papers and bulletins, that feature physical land conditions and land use. In addition, Dr. Steele recently prepared two papers that were accepted by the Grolier Society for use in a reference set to be published under the name of *The Book of Science.*

The professional title of soil conservationist is used in at least two different senses. Each appears to be appropriate for its purpose. A narrow definition is the one set up by the Civil Service Commission as a guide for employment in Federal agencies. *A soil conservationist by Federal classification standards is one who does professional work involving application of two or more specialties to achieve soil and water conservation.* Specialties recognized in this connection are agronomy, biology, engineering, forestry, range management, and soil science. Persons who work entirely within one of the specialties carry their specialized titles even though their work may be entirely in the field of soil conservation. *Our Soil Conservation Society of America, on the other hand, admits to membership anyone who works on a professional level in the field of soil and water conservation.* We need have no trouble with the two definitions, but we may need to remember at times that the Civil-Service definition is a narrow one.

Professional soil conservationists work with and in many respects are supported by subprofessional workers. Other people contribute to soil conservation through their semi-professional interest and activity. In turn, a great many more persons have a non-professional interest in soil conservation. We should utilize fully the work of each of these groups, but we do a disservice if we expect a member of any one group to take on too rapidly the functions of one of the others.

A subprofessional soil conservationist must know how to do some of the practical work extremely well. The position is recognized by title in the Federal service, and many persons in private employment carry on similar expert work. A contractor who builds terraces, or any number of practical farmers and other land operators may possess true subprofessional competence. The subprofessional person knows techniques and can perform some of the work sometimes done by a professional man. He knows less of the scientific background and, therefore, cannot adapt the techniques to new and different situations with as much assurance as the professional. He may have received most of his training and skill through experience rather than formal education. He is an indispensable man in getting soil conservation work done. In research organizations much of the necessary data can be accumulated by subprofessional people.

A brilliant subprofessional man can achieve professional competence through self-study without formal college graduation. Not many are willing to make the effort, but a few have succeeded. We must insist, however, that only competent people bear the professional label. Procedures and standards for examining self-educated candidates in the profession of soil and water conservation are now non-existent. They may have to come some time from the profession itself.

Other Professions Have Interest in Conservation

The semi-professional soil conservationist has considerable technical knowledge of the subject matter but works indirectly with land managers rather than directly on the land. Many people who manufacture or sell farm equipment or supplies, who buy or process farm products, or who have other contacts with farmers, are finding that they can benefit if they know something about soil conservation. The knowledge that they need can be obtained very largely from books and training courses, supplemented by talks with practical farmers and with soil conservationists. The person who possesses semi-professional knowledge can advance to subprofessional competence by serving a period of apprenticeship. The subprofessional must possess skill in addition to knowledge. He must be able to do things.

Teachers in all city and town schools and in rural elementary schools should have at least a partial semi-professional grasp of soil conservation. Many teachers' colleges now offer the necessary training, although I do not know whether it is to all or part of their students. In rural high schools the needs are more specialized. The teacher of agriculture or of biology there should possess the training and preferably at least part of the experience that is required of a professional soil conservationist.

Members of many different professions, such as attorneys, ministers, physicians, writers, and editors, may have an active interest in soil conservation. As a rule their interest in this subject is semi-professional, although they are professional persons in their own field.

We also have people whose interest in soil conservation is active but non-professional. This group would include, ideally, all urban and rural non-farm people who are not included in the other groups. At the present time large numbers of these people still have heard little or nothing about soil conservation.

Farmers do not belong in any one of these groups. A small number have true professional training and qualifications as soil conservationists. A very large number have true subprofessional skills and attainments.

Written materials about soil conservation are needed by each of these groups. As professionals we have our Society's JOURNAL, technical guides and handbooks, and scientific publications. Subprofessionals use the same types of materials. The semi-professional needs are very different and to my knowledge are not being met very well at present. Non-professional needs are being met to an increasing extent through newspapers, general magazines, and other publications, although the coverage is

still far from adequate. The needs of the different groups are further complicated by vastly different reading habits and capacities.

Opportunities in Profession are Great

No one has yet appraised fully the opportunities for professional service in the field of soil conservation. Griggs mentioned some of the possibilities in this field and in other fields involving biology in 1945 (2). Each of us would do well to read his paper carefully, and to re-read it at suitable intervals. He stresses the need for consulting specialists in the control of soil erosion and in other branches of applied ecology. He states further, "It is important to realize that our professions would grow and prosper irrespective of whether such services were provided on a fee basis, as are physicians and lawyers, or from public funds, as are county agents. There are advantages and disadvantages of each type of compensation for the consultants." At present the professional soil conservationists are employed almost entirely by public agencies or by corporations, and there are few in private practice serving individual clients. It is entirely possible that a system of private practice might be developed if trained men can be made available as demands come for their services. Commercial farm-management concerns, for example, are advising more and more on physical and biological aspects of land management as farmers ask for this kind of help.

Griggs also states, "The essence of professional service is that it should provide what clients need—not necessarily what they want." We call a doctor because we believe that he can help us. We take his medicine whether we like it or not because we trust his professional judgment. A comparison with professional soil conservation work is far from rigid but certain similarities exist.

The people who can use our professional services need to know that such help is available. The medical profession has advanced in a few generations from a more or less heterogeneous mixture of the legitimate healing arts with unfounded superstitions to a recognized profession, based on an ever-growing body of science and composed of numerous specializations. This growth and accompanying prestige have been brought about in part by self-discipline originating within the profession, and in part by a vigorous and well-executed program of promotion. Soil conservationists now have a similar opportunity to promote our profession by a series of dignified activities to let the farming public and the urban public know what we can do.

Many groups of scientists are only beginning to understand the concept of professional practice as distinguished from other types of scientific work. Griggs stated the case well in the paper just mentioned. He wrote as a biologist and also as a representative of the National Research Council. He stressed in particular the folly of considering teaching and research as the principal employment opportunities for trained biologists. A similar assumption, however, was made with respect to large groups of scientists in the Steelman reports on Science and the Public Policy in 1947 (3). Actually there are many people who could profit financially from the services that trained biologists, soil conservationists, and other professional people could render.

The Steelman reports mention the functions of university science departments in relation to professional schools of agriculture, education, engineering, pharmacy, home economics, and medicine. They do not contain, however, any further estimates of the needs of these professions in relation to the entire problem of training manpower for the sciences. We find further that the count of Government scientists that is given appears to include most of our professional group now working in soil conservation. It would appear that if the professional people are to be included in the statistics, their functions should be mentioned and the needs for trained people should at least be suggested. The reports, to be sure, are concerned with science and scientific research rather than with professional services. The job of estimating professional needs and opportunities is an additional one that ought to be explored fully by each of the professions concerned, including ours.

Professional Training is Important

Undergraduate training in soil conservation at the professional level is fairly satisfactory at the present time. The student can find a curriculum in soil conservation at any one of 11 or more different agricultural colleges or universities, and courses in soil conservation at nearly all the others. The curriculums in soil conservation are designed to train students specifically for soil conservationist positions in the Civil Service and for similar work. Many of the students who major in agronomy, engineering, forestry, or soils are eligible for professional work either as specialists or as soil conservationists in the Civil-Service sense. Many institutions other than the agricultural colleges also train men for professional work that can be applied in soil conservation.

Undergraduate students now have an opportunity to supplement their professional training with practical work in soil conservation. A student after two years of suitable college training may enter a competitive examination for conservation aid in the Federal service. Successful applicants do subprofessional work between college terms. They are paid, of course, for the time spent actually on duty. The work experience helps them choose their profession with confidence, and helps the employing

agency in recruiting and placing able men. Promotion to a professional grade is possible after graduation without further examination or red tape.

In graduate schools the opportunities to acquire advanced training as a professional soil conservationist are not so satisfactory. Programs of graduate study in virtually all the scientific departments are built around research rather than the concept of professional service. The candidate for an advanced degree spends about two-thirds of his time taking courses, and the remainder doing original research. The system works well when the candidate is one who has capacity for research, when that fact is recognized by his advisers early in his undergraduate life, and when there is an opportunity for him to continue in creative research after his degree is earned. One trouble is that there are ordinarily more able men than there are full time research positions, and that the graduate schools by and large try to train all of them for research. As a result the substantial needs that exist for soil conservationists to work professionally in the public programs and in private employment are not met adequately. The additional unknown opportunities for soil conservationists to engage in private practice of strictly professional character are not met at all.

The remedy may require some re-orientation of work in graduate schools. Courses and programs of study leading to increased professional competence rather than training strictly for research will be needed. Possibly a professional degree or certificate of some kind should be introduced. If so, it should be granted only after the candidate demonstrates true professional competence. Concentrated courses that could be completed within three or four weeks might be taken by some practicing soil conservationists, Federal employees and others. A "refresher" course or a new subject might be taken every two or three years by someone in Government service without the monetary loss now sustained by a return for a full term of university training. Concentrated courses at universities might also be utilized for in-service training by some of the Government agencies if regulations permitted.

Professional Standards are Needed

Sooner or later soil conservationists must come to have a fairly definite set of professional standards. Several possibilities are open. The Civil-Service standards for Federal positions are helpful, but they are written for the specific purpose of classifying Federal positions. They are distributed to the classification officers concerned and do not ordinarily reach the individual members of the profession. We can ask or perhaps expect our employing agencies to state from time to time what a soil conservationist is and what he does. Certainly some of this will be done, and if we want to we can stop there. *A third possibility is to work actively within the profession, preferably through our Society, to accomplish one or more desired objectives. For example, we might* (1) *describe professional standards;* (2) *clarify the status of professional, subprofessional, semi-professional, and non-professional activities in this field;* (3) *inform other groups, including present and prospective clients and the general public, about the nature and value of professional services available in soil conservation;* (4) *formulate and publish a code of ethics;* (5) *distribute an approved list of professional schools; or* (6) *establish a system for examining and granting some kind of recognition to candidates who wish to engage in private practice on a contract or fee basis.*

Any such activities, if undertaken by our Society, should proceed slowly and with the utmost caution. The professional record of soil conservationists up to the present is good. Our reputation for doing a thorough, honest job is well established. Our profession is strong because the concept of our job grew spontaneously in the minds and hearts of several thousand trained men. Our professional society will acquire corresponding strength if its officers and other leaders are able to obtain, summarize, and carry out the wishes of the members, and exercise at the same time a constructive, dignified and thoroughly professional leadership. All indications at present are that this will be expertly done.

Let me make it clear that a professional society alone cannot do much to advance the profession. Prestige cannot be created solely by the officers and council members, no matter how able they are or how well they work together. But prestige will accrue if every member of the profession knows his job and works at it unselfishly. Then we can work together to accomplish some of the things that any one person, however able, cannot accomplish by himself.

LITERATURE CITED

1. Conant, James B. The Role of Science in Our Unique Society. Science 107, 77-83, January 23, 1948.
2. Griggs, Robert F. Biology and Agriculture in the Postwar World. Science 101, 235-239, March 9, 1945.
3. President's Scientific Research Board, John R. Steelman, Chairman. Science and Public Policy. Five volumes: 1, A Program for the Nation; 2, The Federal Research Program; 3, Administration for Research; 4, Manpower for Research; 5, The Nation's Medical Research. U. S. Government Printing Office, 1947.

The Legume Nodule Story

JOE C. BURTON

Legumes have always played an important part in soil building. Their real significance, however, was not too well understood until 1888. Since then the place and importance of legume nodules has been well documented through experiments and field observations.

IT WAS ALMOST three hundred and fifty years after the first pictures of nodules appeared in the literature before the real significance of the root nodules on leguminous plants was understood. In 1888 Hellriegal and Wilfarth, two German scientists, reported on their classical experiments in which they grew leguminous plants and found that legumes grown in sterilized soil did not thrive as did leguminous plants grown in unsterilized soil. They also reported that the plants grown in the sterilized soil did not bear nodules on their roots as did the plants grown in the unsterilized soil. They associated for the first time in history the presence of nodules on the roots of leguminous plants with the ability of these legumes to grow vigorously.

In the work that followed it was soon found that the nodule bacteria isolated from the nodules of one leguminous plant would not cause nodulation on all legumes. It was also found that some leguminous plants did not have nodules at all as they were found in Nature or even when bacteria isolated from other legumes were placed in the soil in which the plants grew. No explanation was found for the occurrence of non-nodulating legumes but it was found that the nodulating legumes could be divided into groups, the members of which would form nodules when inoculated with bacteria isolated from the nodules of other members of the same group. These groups were called "cross-inoculation" groups. At the present time there are twenty-three such groups and there are still many nodulating leguminous plants which have not been classified.

Strain Variation and Host Specificity

It was soon noted that all nodulated plants did not grow with the same degree of vigor. In fact, Nobbe and Hiltner were granted a patent in 1898 based on their idea that each legume trained, adapted, or in some way selected the bacteria in its nodules and that a particular plant would grow best when inoculated with bacteria isolated from the same species of plant. The alfalfa plant grew best when inoculated with nodule bacteria isolated from alfalfa, and peas grew best with bacteria isolated from peas.

The prevailing idea was that nodule bacteria producing good nitrogen fixation on one plant in a group would also produce good nitrogen fixation on other plants in the same group when the "cross-inoculation" groups were established. This, however, was soon proven to be untrue, and the concept of strain variation and host-plant specificity entered the picture.

Strain variation is defined as variation in efficiency of different strains of nodule producing bacteria on a host plant. Host-plant specificity is the response of the host

Figure 1. Top—Nodulation on soybean produced by effective strain of root nodule bacteria. Bottom—Nodulation on soybean produced by ineffective or parasitic strain of root nodule bacteria.

Joe C. Burton is Director of Research for The Nitragin Company, Incorporated, with headquarters at Milwaukee, Wisconsin. Mr. Burton originally presented this paper at a meeting of the Milwaukee Chapter of the Soil Conservation Society of America.

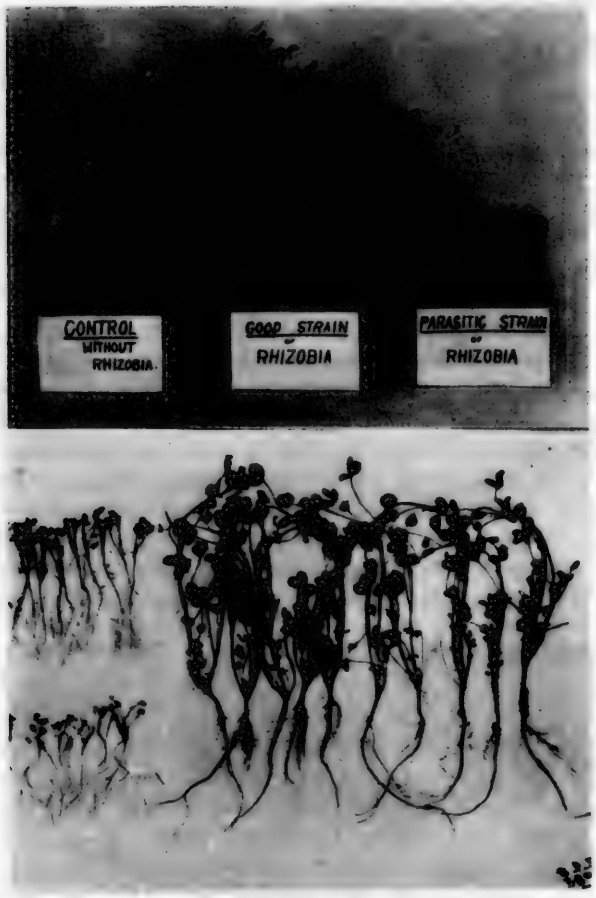


Figure 2. Top—Nitrogen fixation by alfalfa inoculated with good strain of rhizobia and parasitic strain of rhizobia. Bottom —Upper left corner. Nodulation produced by parasitic strain rhizobia on alfalfa—right nodulation by effective strain, lower left—control without nodules.

plant to different strains of the bacteria able to produce nodules on that host. The first term attempts to define the part played by the nodule bacteria and the second term the part played by the host plant in a symbiotic nitrogen-fixation relationship. With the assumption that all strains of nodule bacteria are effective nitrogen fixers on at least one legume the terms become synonymous.

Nodule Patterns

As the phenomena of strain variation and host-plant specificity were being investigated, correlations between nodule patterns and nitrogen-fixation efficiencies were also studied. The strains producing the largest number of nodules were considered to be the most efficient.

Figure 1 shows the fallacy of using nodule numbers as a criterion of efficiency. The soybean roots on the top show the nodulation produced by a very efficient nitrogen fixing strain of the bacteria, and the roots on the bottom the nodulation produced by a parasitic strain[1] of soybean bacteria. If nodule numbers had been used as the criterion of efficiency the parasitic strain would have been considered most efficient.

This same phenomenon is demonstrated on alfalfa in Figure 2. The nodulation produced by the parasitic strain on alfalfa is shown to the left of the bottom photograph. The highly effective nitrogen fixing strain is shown at the right. The amount of growth produced by the two strains is shown in the top photograph.

Large nodules located in the upper part of the root system around the tap root are usually associated with a highly beneficial relationship between the nodule bacteria and the plant. However, all highly beneficial strains do not produce this type of nodulation. Ineffective or parasitic strains frequently, but not always, produce more numerous nodules than effective strains but they are usually small and scattered throughout the root system. Nodules which are pink on the inside are more frequently produced when a high degree of symbiosis exists. *Nodule volume is now accepted as a much better criterion of efficiency than nodule numbers.* Good strains of bacteria frequently produce a few very large nodules, the volume of which would exceed many times that produced by other strains causing many small nodules. This is shown on soybeans in Figure 1.

Other Factors Affecting Nodulation

The legume nodule is a structure built by the plant on the root in response to the stimulus of the root nodule bacteria. The typical soybean nodule is round and fairly large. The typical alfalfa nodule is small in diameter and elongated. Peas of the sweet variety more frequently produce clusters of nodules while the Alaskas produce a more scattered type of nodulation even with highly effective strains. The yellow lupine produces a ring or sleeve of nodules around the tap root so tightly fused that they appear as a single structure. With all of these legumes, however, the exact type of nodulation will depend on many factors other than the strain or its effective symbiosis. The structure of the soil, moisture conditions at planting, rainfall, seed bed preparation, fertility level, pH of soil, fertilizer placement, rotation, crop or variety adaptation, disease, insects, and climatic conditions will all have their influence on the size, number, and location of nodules. With all these contributing factors it is little wonder that correlations between nodulation patterns and effectiveness have been difficult to define.

Nodulation patterns observed with a strain of rhizobia

[1]By parasitic is meant the bacteria use food from the plant and do not fix any nitrogen for the plant's use.

(*Continued on page* 94)

Erosion Damage to River and Harbor Works

JOHN J. NOLL

Soil erosion damages are far reaching in effect. This is illustrated by the damages done to reservoirs, to harbors and rivers, to oyster beds, and other forms of aquatic life. Mr. Noll, through extensive studies, has been able to ascertain the amount of silt removed from certain harbors, the costs involved, and the relationship of these damages to land areas.

THE DESTRUCTION of our farmlands by soil erosion is now generally recognized. It would be a serious enough problem if the damage ended with the farmland.

Erosion, however, is only the starting point of a whole series of damages caused by the eroded material as it is carried seaward.

Even after reaching salt water, erosional debris may destroy oyster beds and other valuable aquatic life. Along the way, sediment may cause increased frequency and destructiveness of floods by filling stream channels. Filled channels also cause formerly well-drained bottom lands to become poorly drained, many of them too wet for continued agricultural use. Sediment washed into storage reservoirs gradually destroys their usefulness by reducing storage capacity. Deposition of coarse sterile sediments, such as sand, on agricultural bottom lands decreases soil productivity. The finer eroded materials, carried as suspended load, increase the cost of treating the water we drink and use in industry.

The usefulness of our harbors and navigable rivers is constantly being threatened by the products of erosion. Harbors are an irreplaceable natural resource. The entire economy of many of our cities is based on navigable harbors. Millions of dollars are spent annually to maintain our navigation system. Constant dredging to remove eroded material from waterways is an important part of the price we pay for soil erosion.

A study was made of the river and harbor operations carried out by the Department of the Army, Corps of Engineers, in the southeast. The study included all improvement of rivers and harbors in Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, and Kentucky.

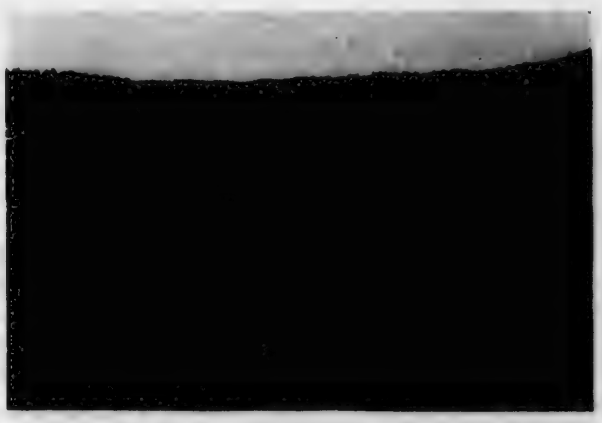
Basic data were obtained from annual reports of the Chief of Engineers. Estimates were made to determine what portion of the total costs and amounts of material removed by dredging was directly attributable to soil erosion. Since all of the material obstructing navigation channels is not a direct product of upland erosion, it was necessary to consider each project separately to determine the source of sediment. Deposits, particularly outer bars, may be made up of shore or bottom materials moved by waves, tides, coastal currents, or may be of mixed origin. Overall maintenance costs were not used. Only the actual dredging costs of each project were considered.

During the fiscal year ending June 30, 1946, a total of 33,941,000 cubic yards of material was removed by dredging from all southeastern rivers and harbors. The dredging cost was approximately $4,947,000. Of these totals, upland erosion was considered responsible for an estimated 21,970,000 cubic yards of material, which cost $3,084,000 to remove.

During the following (1947) fiscal year, 15,226,000 yards of material removed by dredging was considered to be directly attributable to soil erosion. The dredging cost was $2,493,000.

Soil erosion was directly responsible for an estimated 37,196,000 cubic yards of sediment (approximately 30,128,760 tons) for the two-year period mentioned above at a cost of $5,557,000. This amount of soil material is equivalent to a six-inch loss of topsoil from 46,110 acres of farmland.

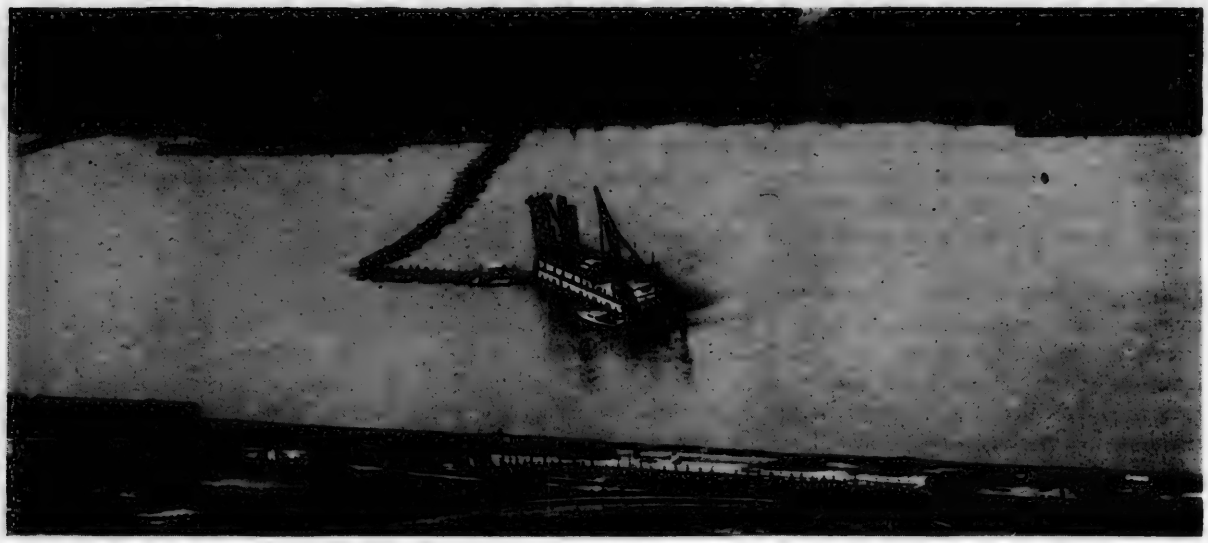
Savannah Harbor in Georgia affords an outstanding



Soil Conservation Service Photo

Figure 1. Coarse sands deposited by floods have ruined this bottomland on a tributary of the Appalachicola River in Georgia.

John J. Noll is associated with the Soil Conservation Service and holds the position of Sedimentation Specialist in the Water Conservation Division. His headquarters are at Spartanburg, South Carolina.



Official photograph by Lanier, Savannah District, Corps of Engineers, Savannah, Ga.

Figure 2. Aerial view of dredging operations by Corps of neers, in Savannah River Channel.

example of how erosion damages navigation projects. The entrance and lower 22 miles of the Savannah River have been improved to form this harbor.

Almost constant dredging is required to keep channels clear because of the enormous amounts of eroded material brought in by the Savannah River. During the period July 1, 1945 to June 30, 1946, more than 10,526,000 cubic yards of sediment were removed from Savannah Harbor and waterway at a cost of approximately $965,956. About ten per cent of the dredged material was sand and 90 per cent was silt. Practically all of the sediment removed was considered to be soil material washed from eroding uplands. For this one year alone, the amount of material dredged from Savannah Harbor was equivalent to a one-inch loss of topsoil from 78,294 acres of farmland, or a six-inch loss of topsoil for 13,049 acres of farmland.

Sedimentation surveys of numerous reservoirs throughout the southeast show an average rate of sediment production of about one-half acre-foot of sediment produced annually by every square mile of drainage area. Rates of sediment production, however, show wide variation. The Piedmont Plateau has one of the most serious erosion problems and very high rates of sedimentation. A typical Piedmont stream is never clear. Its reddish color is a constant reminder of almost continuous soil loss.

A sedimentation survey of Lake Issaqueena, located in a very badly eroded section in northwestern South Carolina, indicated that the watershed above the reservoir was producing sediment at the rate of 2.19 acre feet annually per square mile of drainage area.

The heavily forested Blue Ridge Mountain Area represents the opposite extreme. Where the woodland has been adequately protected from fire, grazing, and overcutting, rates of sediment production are negligible.

The many damages caused by the products of soil erosion clearly indicate its far reaching effects. Not only the farmer, but everyone is in some way directly affected by soil erosion.

Soil and the Church

So great has been our prodigious waste that shortages in every field are staring us in the face, and we are becomingly genuinely concerned for our future wants and security. When the history of America is written, Free Enterprise, of which in its largest sense, the church and agriculture are both a part, will be indicted the most severely on its waste of a great nation's natural resources. The church must come to know and lay these facts upon the conscience of the nation.

History must be brought to bear upon this problem. No institution has a better command of history, nor is better fitted to point out what happens to people when their soil is destroyed, than the church. The rapid decline of ancient Israel, whose history is so well known to the church, is the story of eroded soils and destroyed natural resources. The pharaohs of Egypt built a great civilization on the rich soil of the Nile; but now that once beautiful valley is a land of dry and drifting sands, and impoverished people.—REV. L. H. HASS, *Before the 1948 Annual Meeting of the Soil Conservation Society of America, Cincinnati, O.*

Recent Research Reviews

JAMES H. STALLINGS

The Reviews by J. H. Stallings that follow are a regular feature in the JOURNAL. It is hoped that the projects reviewed from time to time will be helpful to conservationists everywhere. Members of the Society are urged to indicate their interest in the kind of research work that should be reviewed.

A Summary of the Economics of Soil and Water Conservation in McLean County, Illinois. *1936-47. By* E. L. SAUER. *USDA-SCS, Mimeo. August 17, 1948.*

Although for a year or more after a conservation plan is adopted, net income may be lower than it would ordinarily be, studies made in different areas of the state show that money spent on conservation is a sound investment. In addition to improving both present and future productivity, conservation practices usually increase the net income in two to six years, depending on the extent of the farm's conservation needs. The returns provide a safe basis for establishing credit to put the conservation program into effect. Although the net income may be reduced temporarily, the productive value of the land increases immediately, protecting the financial position of the landowner until the long-time benefits of conservation can accrue.

Evaporation from Water Surfaces in California. *By* ARTHUR A. YOUNG. *USDA-SCS, State of Calif. Dept. of Pub. Works, Div. of Water Resources, Bul. No. 54-A. 1948.*

This is the second of two volumes which together comprise a report on evaporation from water surfaces in California. The first volume, published in 1947 as Bulletin No. 54, is essentially a summary of the basic records here presented as Bulletin No. 54-A.

Consumptive Use of Water Studies in Colorado Basin. *By* D. F. PETERSON, JR., *and* WAYNE D. CRIDDLE. *Farm and Home Science, Vol. 9, No. 3, pp. 6-7 and 19. September 1948.*

The authors discuss the main features to be covered in extensive consumptive use of water studies to be conducted in the Ashley Creek basin in Emery County. The studies involve a study of streamflow, ground water, climate, evapo-transpiration rates, soil moisture depletion, and land use.

Revegetation of Sandblows in Vermont. *By* JOSEPH B. KELLY, A. R. MIDGLEY *and* K. E. VARNEY. *Vt. Agr. Exp. Sta. Bul. No. 542, May 1948.*

Weeping lovegrass spells doom to Vermont's sandblows. Weeping lovegrass withstands the adverse conditions in sandblows and is inexpensive to establish. The blow areas should be laid out in alternate 12-foot and 24-foot strips at right angles to direction of the prevailing wind. The 12-foot strips should be planted to lovegrass and black locusts and the 24-foot ones to red pine. Apply fertilizer to the grass-locust strips as soon as the frost is out of the ground in the spring. Apply ground limestone and 5-10-10 fertilizer at the rate of 1,000 pounds each per acre. Broadcast weeping lovegrass seed, at the rate of 3 pounds per acre and rake the lime, fertilizer, and seed into the surface in one operation. Next plant black locust trees at 6-foot intervals in two staggered rows in the grass strips, putting a handful of 0-20-20 fertilizer in the bottom of each hole. Early the second spring, or sometime the fall after planting the lovegrass, plant red pine in the 24-foot space between the grass-locust strips, using 6-foot spacing in four staggered rows.

Some Rates of Fertility Decline. *By* W. A. ALBRECHT. *Better Crops with Plant Food, Vol. 32, No. 8, pp. 21-24 and 42, October 1948.*

As a consequence of the rapid decline in fertility and the slow rate of its restoration, the more productive soil areas under cultivation are shrinking. Land is being taken out of production faster than we desire. Some suggested rates of fertility decline are coming to us from farmer experience and from soil-crop studies. They are putting the rate of disappearance of the soil fertility more nearly on a true basis. They are giving answers in numbers of years by which we may well look into the future. Unfortunately, however, these numbers of years before yields will be put below continuance of economic production are much smaller than we like to have them.

The transition from a virgin soil supporting good permanent timothy to one with only broom sedge took place within a period of 60 years. It takes only 40 years in the Santa Rita Mountains to exhaust the soil fertility by only grazing, and to push the soil's productivity down from good range for cattle to mesquite brush. Under tillage, the decline of the fertility of the world would be expected to be more rapid. At Sanborn Field it took only 40 years for land cropped to wheat continuously to become incapable of producing wheat.

The Influence of Forest Cover on Snow-Melt. *By* H. G. WILM. *Trans. Amer. Geophysical Union, Vol. 29, No. 4, Part I, pp. 547-556. Aug. 1948.*

There is presented a survey of important literature on the effect of forest cover on snow-melt, with recent re-

sults of investigations in the Fraser Experimental Forest, near Fraser, Colorado. It is shown that forest management by selective cutting influences greatly the accumulation and retention of snow on the ground. The evidence supports J. E. Church's fir forest possessing a maximum number of glades as the most desirable type for snow conservation.

Rates of Runoff for the Design of Conservation Structures in the Central Great Plains of Nebraska and Kansas. *By* JOHN A. ALLIS. *USDA-SCS-TP-69, Washington* BE, *D. C., August 1948.*

This publication is one of a series containing information for use where peak rates of runoff are required for the design of hydrologic structures. Such factual information is needed for the economical design of spillways, diversions, culverts, terrace outlets, and other structures.

It is recognized that an 8-year record of surface runoff from small agricultural areas is insufficient data upon which to base conclusive recommendations. It was felt, however, that the need for information on peak rates of flow that might be expected from such areas justified the immediate publication of this report.

Runoff Water as an Agent in the Loss of Soluble Materials from Certain Soils. *By* JAY C. BRYANT *and* C. S. SLATER. *Iowa State College Journal of Science, Vol. 22, No. 3, pp. 269-312. April 1948.*

Filtered runoff water from 8.01 acre plots, representative of two soil types and seven kinds of cover, were analyzed for materials in solution. In all, 39 separate runoffs that occurred over a 13-month period were analyzed.

Small amounts of soluble materials were lost in runoff water. Soil type and cover had a marked effect on both the amounts and concentrations of the solutes lost. Their effects appeared to be related to variations in solute concentrations at the soil surface and to the relative rates of infiltration and runoff.

The Use of Land-Capability Maps for Rural Real Estate Assessments. *By* ROY D. HOCKENSMITH. Mimeo, *Washington, D. C. October 4, 1948.*

The author discusses the use of land-capability maps as a guide for rural land assessment. USDA-SCS, paper presented at the 41st Annual Conference on Taxation, sponsored by the National Tax Association, Denver, Colorado.

How to Inventory Grazing Resources and Develop a Ranch Conservation Plan. *By* B. W. ALLRED. *Sheep and Goat Raiser, Vol. 29, No. 3, pp. 28-32, San Angelo, Texas, December 1948.*

Soil Conservation on range land is obtained primarily by improvement of the vegetation. It is necessary, therefore, to know the significance of various combinations of plants and other conditions found on the range. Determination of range condition is, in effect, a summary of the kind and amount of climax and other vegetation found on each site.

Grazing capacity of the range is important, but the operator must know much more than this; particularly does he need to know the present condition of his range, its productivity, and the improvement in the kind, amount, and production of the range forage to be expected from proper use and treatment. A knowledge of the principal factors of range condition—the inherent potentialities of major land sites, the climax and invading vegetation in controlling erosion, and the quantity and value of important range plants for grazing—is essential to an understanding of grazing problems.

The author explains how rane users and range planners can learn to evaluate range sites, condition classes and safe grazing capacity and apply this knowledge to a given range.

Conservation Practices for Tobacco Lands of the Flue-Cured and Maryland Belts. *By* T. L. COPLEY, CLARENCE S. BRITT, *and* W. B. POSEY. *USDA, Mis. Pub. No. 656, 1948.*

This publication treats briefly of the nature and extent of erosion on the lands of the Flue-Cured and Maryland cigarette tobacco belts, and gives some practical mechanical methods of soil protection, which safeguard the specific qualities of leaf demanded by the tobacco trade. Practices, such as row grades, contour cultivation, crop rotations, winter cover crops, and mulching were included in the study.

Soil Moisture and Wheat Yields on the High Plains. *By* H. H. FINNELL. *USDA Leaflet No. 247, 1948.*

Above-average wheat yields may be had in the High Plains area by saving and using the rain that has fallen before the crop is planted. Moisture stored in the soil from previous rains often contributes as much to the wheat harvest as do the rains that come after the crop is planted. Soil moisture at planting time is the most important measurable factor that will affect the success of a wheat crop. The amount of soil moisture, as measured roughly by the depth it has penetrated, can be used to forecast wheat yields within certain limits.

Hydraulic Characteristics of Vegetation for Vegetated Waterways. *By* W. O. REE. *Paper presented at the meeting of the Amer. Soc. of Agr. Eng., Chicago, Ill., Dec. 13-15, 1948, USDA-SCS, Stillwater, Okla., Mimeo.*

The author presents the results obtained from studies conducted to determine the hydraulic characteristics of vegetation in channels.

BOOK REVIEWS

THE STUDY OF PLANT COMMUNITIES. *By* HENRY J. OOSTING. *W. H. Freeman and Co., San Francisco. 389 pp., il. 1948.*

The subtitle, "An introduction to plant ecology," characterizes this book more accurately than the title. It not only indicates the broad scope of the contents, but suggests the level and manner of treatment.

Definitely, the book will not replace the classics in the field. Rather, it will prove a more effective tool in preparing undergraduates for the more advanced writing already available. Growing out of teaching notes, and intended specifically as a college text, it aims at a simple but comprehensive presentation of basic information. This goal is achieved with outstanding success.

The text is more comprehensive than its title, which suggests a treatise on synecology. Approximately a third of the pages are devoted to a treatment of autecology, or "Factors controlling the community: the environment." Another sixth has to do with "Practical Considerations," or applied ecology in land use, conservation, and human relations. This makes for an unusually well balanced and complete discussion of the entire field of ecology. Although it is labeled "plant" ecology, the broader concepts of bio-ecology and related human ecology are evident throughout.

Especially to be appreciated is the style of writing. Clear and simple language sustain interest and understanding in a subject notoriously difficult to read. Yet there is no writing down nor popularizing. Here are 361 pages of straightforward unfolding of facts, well documented by 276 references, and supplied with a good index.

The "dynamic" viewpoint prevails throughout the book. Confirmed followers of the so-called Clementsian school of ecology may be disturbed at places by mild departures from views considered authoritative.

This is especially noticeable in the chapter on climax communities, and particularly in the classification of the climaxes. A detailed comparison of the two systems is not possible here, but a few points will illustrate. Oosting recognizes five forest formations, instead of Clement's six. He relegates the Lake Forest to the rank of a transitional association in the Deciduous Forest Formation. The latter is divided into six climax associations centering around the Mixed Mesophytic Forest. Western forests are described in terms of altitudinal zonation in the Rocky Mountain and Sierran systems. Grasslands are classified as Tall Grass, Mixed Grass, and Short Grass, although it is recognized that "the climax nature of short grasses has been questioned, and the community has been described as disclimax resulting from overgrazing an area that would otherwise support mixed prairie. This interpretation is gradually gaining favor." Desert vegetation is described more in biogeographical terms as the Great Basin, Mojave, Sonoran, and Chihuahuan deserts.

In the field of vegetational analysis, about equal attention is given to the quantitative methods of American ecologists and the phytosociological procedures of the Europeans. The usefulness of both systems is upheld.

In the chapter on applied ecology modern ideas in land management, soil conservation, forestry and range management are well presented. As in the rest of the book, there is little new material but a competent survey of the best information available.

The case for an ecological basis for land management is well presented. "Man is rapidly becoming the earth's dominant organism," the author states. "To an increasing extent, natural communities survive because he tolerates them, are modified to suit his purposes or fancy, or are destroyed sometimes through his carelessness, but usually so that land may be used for agriculture, industry, or other activities. . . . All this is necessary from our modern point of view and will continue, perhaps at an accelerated rate, as populations increase and the earth is more completely occupied and used.

". . . A problem today, which will become greater in the future, is that of how to use such natural resources to the fullest extent without jeopardizing their continued availability for future needs."

Throughout his discussion of forestry, range management, and the other phases of land use, he argues for the principle of approaching as nearly as possible the climax community for every habitat.

Of forests: "The less cultural practices tend to modify the natural trends of succession, and the more nearly the desired forest is to the climax of the region, the less the effort and expense there will be in developing and maintaining it."

Of range: ". . . practices of management which least disturb the natural balance of grassland and its environment are most desirable."

Of croplands: "We must have crops, but, if climax vegetation utilizes natural conditions most effectively—and that seems reasonable—are our methods of cultivation the best we can use for obtaining our crops? . . . Perhaps we have gone too far in producing unnatural conditions."

The chapter is generously studded with familiar pho-

tographs from the Soil Conservation Service and Forest Service. It is a thought-provoking chapter. In fact, the entire book would be rewarding reading, not only to college students, but to professional conservationists and to laymen concerned with understanding our land resources.

—BEN OSBORN, *San Angelo, Texas.*

CRY, THE BELOVED COUNTRY. *By* ALAN PATON. *Charles Scribner's Sons, N. Y. 1948. 278 pp. $3.00.*

Here is a novel of special interest to the soil conservationist. It is a story about South Africa—about an old Zulu parson and what racial unrest did to his son, his family, and his friends. Beautifully written, it tells also of how the people turned away from the land, and how "in the valleys women scratch the soil that is left, and the maize hardly reaches the height of a man." Good reading for the human tale that it tells, "Cry, the Beloved Country" will be especially satisfying to those who work with the soil.

—E. H. GRAHAM, *Washington, D. C.*

FOREST INFLUENCES. *By* JOSEPH KITTREDGE. *McGraw-Hill Book Company, Inc., N. Y. 394 pp. 25 fig. 1948.*

The term "forest influences" usually creates interest among those who hear it for the first time. They expect to find a third word following the predicate; and somehow feel let down when they learn that "influences" is not a verb but a noun. One could continue and say, "Forest influences climate, water and soil," but such a title is too lengthy and unhandy to use. Besides, it removes the mystery the two words leave with the hearer.

"Forest influences" however is a subject which has attracted great attention for many years. Many popular beliefs as to the influence excited by forests have excited the public. The merits and demerits of these beliefs have been debated for decades, pro and con by conservationists, foresters, engineers, geologists, meteorologists, and the general public. These debates have been marked by the fact that they have been carried on mostly with much fervor, many false notions, and few data. If one should follow one school completely, one must be convinced that forests cause rain, prevent drouths, control floods, modify the climate, cause rivers to flow, yield absolutely pure water, cure tuberculosis, and perform other miracles. Yet it was out of these beliefs some fifty years ago, that conservation in America took form and flowered. Even though today some of us may look down our noses at some of the early statements, we must all recognize in them an appreciation and an understanding of experience. In them also were germs of truth, seeds of vision, and inspiration for the future.

Over the years, the part that forests and related natural vegetation play in soil and water conservation and in meliorating the micro-climate has become better understood. We know more than the generation that preceded us but we still do not know all the answer. Today, yesterday's tenets can be tcarefully scrutinized in the light of wider experience and more careful research. Field studies have provided us with facts to replace opinions. The rapidly growing literature on the subject also shows that logic and reason are overcoming dogma.

Dr. Kittredge in his *"Forest Influences"* has summarized the results of many of these investigations and brought them together under one cover. In doing so he has performed a herculean task for the literature is indeed scattered. Kittredge has gone farther, he has summarized some findings which are in manuscript and which in all probability will remain so. He has now provided the technician and student with the basis on which many present day principles are founded.

The book is well organized. After fine introductory material covering several short chapters, the author starts us out with a discussion of climate broken down into radiation, temperature, wind, humidity, and precipitation. He leads us gradually into his discussion of forest litter, soil, water relations of trees, run-off and erosion. He winds up with chapters on erosion control and watershed management. At the conclusion of each chapter he provides us with a short pithy summary, the separate paragraphs sharply dealing with only one subject. The best chapters appear to be those dealing with forest litter and transpiration. The poorest those dealing with solar radiation and precipitation.

It is difficult to evaluate such a book. It is not one to read at a single sitting. It is a book of reference for all those who wish to have some understanding of the processes by which forests exert their effects. It is a valuable documented tool for the technician who will undoubtedly wish to avail himself at least of the chapter summaries and of the list of 381 references. Teachers of conservation subjects should not be without it. It is a must for the student. It should also be a must for the many foresters and for conservationists generally who desire to understand basic principles, where forests are part of the soil and water conservation movement.

To the informed reader of today, the book is somewhat of a disappointment as it does not include findings later than 1945. The author apparently completed his manuscript about that time. In places, the author has gone into the mathematics of the subject too deeply for the general practitioner, but to the teacher and student, this treament appears desirable though perhaps a little formidable at times. The last few chapters are decidedly out of balance. There is relatively little on watershed management (Chapter 25 has only 6 pages). This is a subject of tremendous importance to the practitioner

and land manager who today is seriously asking what effect various forestry practices will have. By contrast, three chapters, taking up 83 pages, go into the subject of erosion and erosion control.

The book is remarkably free from errors, although it does have some slight imperfections. Legends on maps are not always legible, even with a hand glass, and symbols in the text are not always immediately defined. It is unfortunate that the first figure encountered is complicated. These cannot however detract from the value of the book. The author has done the conservation movement a good turn.

—E. N. MUNNS, *Washington, D. C.*

PROPAGATION OF MINNOWS AND OTHER BAIT SPECIES. *By* J. R. DOBIE, O. L. MEEHEAN, *and* G. N. WASHBURN. *U. S. Dept. Int., Fish and Wildlife Service Circular 12, Govt. Printing Office, Washington, 1948. 113 pp. Price 35 cents.*

The sport fishermen of this country use each year a tremendous number of minnows as live bait. A few fishermen seine their minnows but most of them buy their bait from bait dealers. For the most part the dealers obtain the minnows by seining public lakes and streams. In many places there is a real shortage of minnows in public waters and strict laws regulating minnow seining have been passed or are being proposed. While the natural supply of minnows is decreasing the number of fishermen is increasing. All this makes the problem of obtaining minnows increasingly difficult for the bait dealer. As a solution to their problem many dealers are turning to the propagation of minnows in artificial ponds. Other persons, sensing a commercial opportunity, are becoming interested in minnow production. Thus, a new kind of land use is developing.

Although commercial production of bait minnows is still in the experimental stage, much has been learned in the past few years. This book presents most of what is now known about minnow production. It includes instructions on how to raise earthworms, crayfish, and crickets. The collecting and care of bait species such as hellgramites, May fly nymphs, and leeches is also discussed.

Helpful instructions and suggestions are provided for practically every step in raising minnows. The importance of water source, site selection, and pond construction are emphasized. One is told of the many factors that must be considered in selecting the species of minnow to be raised. Various methods of stocking, fertilizing, and feeding are discussed. The material on harvesting, grading, holding, and transporting minnows will be helpful to experienced as well as inexperienced minnow raisers. The last part of this book describes the life histories of twenty important bait fishes.

This book should be in the possession of anyone interested in or likely to be consulted about the production of live bait for fishing.

—LAWRENCE V. COMPTON, *Fort Worth, Texas.*

NORTHERN FISHES. *By* SAMUEL EDDY *and* THADDEUS SURBER. *The University of Minnesota Press, Minneapolis. 1947. 276 pp., 7 diagrams and 57 figs. Price $4.00.*

Although "*Northern Fishes*" is a book written with special reference to the Upper Mississippi Valley, its usefulness is not restricted to that locality. The first 51 pages of this book discuss such fundamental subjects as lake dynamics, fish populations, management of waters for fish production, laws, and propagation. This makes interesting and profitable reading for anyone who concerns himself with fresh water fishing. It should be emphasized, however, that this material is pointed at northern lakes not at farm ponds. The remainder of the book is devoted to the description and identification of the fishes of the Upper Mississippi Valley. This part of the book will be especially useful to the northern fisherman. It will aid him in the identification of his catch and the descriptions of habitats and food preferences will help him know how and where to fish. More than 150 kinds of fish are described. Eighty-four varieties are illustrated with black and white photographs. Four excellent color plates illustrate nine species.

—LAWRENCE V. COMPTON, *Fort Worth, Texas.*

THE RUFFED GROUSE AND ITS MANAGEMENT IN OHIO. *Bulletin No. 6. Ohio Division of Conservation and Natural Resources. November 1948.*

This is a popular account of the results of a P-R (Federal Aid in Wildlife Conservation) project study of the ruffed grouse in eastern Ohio, augmented by information from other grouse studies in nearby states, especially New York. There are brief descriptions of the bird, its distribution and abundance in Ohio, life history, food habits, cover requirements and relations to weather, predators and man. Management recommendations are made for improving cover by cuttings and plantings and increasing the food supply with the same techniques. Restocking, predator control and setting aside refuges for grouse are discussed but not recommended. A series of 17 line drawings each illustrating a specific management suggestion and including a one-paragraph legend is included at the end. The bulletin is a very useful, "nutshell" reference on the grouse and the series of management practice drawings is especially good.

—FRANK C. EDMINSTER, *Upper Darby, Penna.*

FIELD NOTES AND COMMENTS

Thinning Loblolly Pine in Delaware

Loblolly pine stands should be thinned. The time or age of the trees at thinning will depend on the stand. The thinning operation should not only pay for itself but should give the farmer or landowner a monetary return, even if it's only a few dollars per acre.

In the case of the woodlot shown in the picture, the trees removed were used for pulpwood. As a result of this operation the oppressed, diseased, dying and inferior species were removed leaving the thrifty and potential crop trees. By removing 6-8 cords per acre the remaining trees were assured of less competition for the available plant food and moisture and as a result will grow faster. This in turn will move the final crop or final cutting operation ahead a number of years.

The farmer in this case received one dollar a cord stumpage which was a fair return considering that the trees removed, in most cases, would have died anyhow.

As in most loblolly pine stands in Delaware, hardwoods are a problem. Here the undesirable hardwoods were removed along with the pine and also sold for pulpwood. The only practical way, it seems, of keeping the hardwood population down is by cutting them out and when you can receive a return for them it then becomes a good economic practice. The pulpwood companies buying in this section of Delaware don't want hardwood pulpwood but in this case they took the hardwoods to get the pine, which was a fair deal both ways.

Figure 1. This Delaware scene shows a stand after thinning. All the diseased and other inferior trees have been removed.

Growing loblolly pine in the farm woodlot is good land use in the loblolly pine area of Delaware. As a result of trial and error on the part of the early settlers the farm woodlot has ended up with the least desirable soils and location. Here it is a lack of drainage which happens to make ideal conditions for growing loblolly.

With good management a loblolly pine woodlot will make a fair contribution to the farm income. Starting with a pulpwood thinning followed in a few years by a selection piling cut and then later with a final harvest cut of saw-logs. If the area has been managed properly there will be young pine coming up in the openings and a pulpwood cut will be coming up again in the not too distant future. Loblolly pine, will, with management, be sawlog size in 35-40 years, which is a relatively short rotation.

—H. R. Frantz, *Bethlehem, Penna.*

Support for Society's Land Policy Statement is Far-reaching

Many letters from agricultural, industrial, and Congressional leaders have been received by Lloyd E. Partain, President of the Society during the past two months. They all strongly favor the Society's position—especially the simplicity and practical application of the statement. A few of the letters from members of the Senate and House follow —

Approach is Realistic

Dear Mr. Partain:

I was very much interested in the *National Land Policy* advocated by your organization, and there certainly can be no quarrel with the principles underlying your far-reaching conservation program.

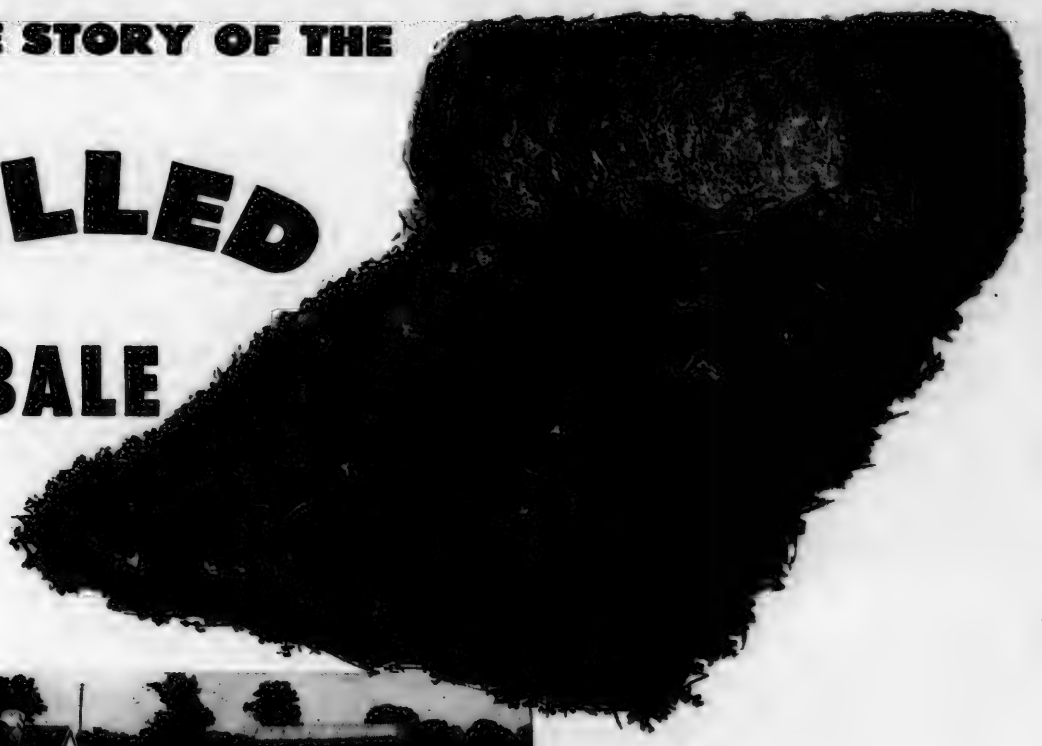
By urging that such activities be spearheaded at the local level, I feel you have taken a very realistic approach to the whole problem. The land owners and users cooperating with the levels of government concerned under the guidance and advice of competent technicians would seem to be an ideal solution.

I assure you that I am gravely concerned with the problems of soil conservation, and that I will give my earnest support to a practical and realistic program that best effects general policy outlined in your resolution.

If I can be of any assistance in these efforts, do not hesitate to write.

Fred Marshall, *M.C., Minnesota.*

INSIDE STORY OF THE ROLLED BALE



You simply unroll it and there it is . . . a thick, soft, leafy carpet of hay. The leaves are still on the stems. The natural protein and color are still there. Livestock show a preference immediately.

Roto-Baling is the new art of packaging hay or straw. The farmer pictured at left is showing how it is properly done. Wide *double* windrows cure fast and make the best rolled bales. (And you travel only ½ as far per bale.)

The ONE MAN ROTO-BALER, for the first time, makes possible home ownership of your own machine. You can save your crop the hour it is ready. Once hay is in the rolled bale, you can breathe easy, *for it sheds rain like a thatched roof.*

ROTO-BALING is setting new standards for preserving hay *quality.*

Double windrows are easily made by reversing direction of raking. Ideal for the job is the new POWER DRIVEN air-tired Allis-Chalmers Side Delivery Rake and Tedder, with selective reel speeds. It steers true, makes straight, airy windrows.

ALLIS-CHALMERS
TRACTOR DIVISION . MILWAUKEE 1, U. S. A.

Way to a Better System

My Dear Mr. Partain:

This will acknowledge receipt of your letter of March 16, 1949 concerning a National Land Policy.

Throughout my years of service in public office, I have always sponsored and supported all measures looking toward the conservation and wise utilization of all natural resources.

Your concise statement entitled *National Land Policy* is one of the best short presentations of this matter that I have ever seen. Many of the recent articles and books on this subject have been content to cite the results of misuse and disuse only, but your one page also includes possible remedies for the situation and shows the way to a better system.

Thank you for writing me on this problem and please be assured that I will remain a friend of intelligent conservation programs during my years in the Senate.

ROBERT C. HENDRICKSON, *United States Senate, New Jersey.*

Agrees with Definition of Land

Dear Mr. Partain:

Thank you for your letter of March 16 with which you enclose a copy of the *National Land Policy*, Soil Conservation Society of America.

I am glad to have the benefit of your suggestions. Soil conservation is a serious problem before the nation and while we have made some headway, we are not practicing it as widely or as intensely as our national well-being requires. I agree with you wholeheartedly that all land should be used in a manner which would insure its continued and permanent maximum productivity and value.

JOHN SPARKMAN, *M. C., Alabama.*

Plans to Have Statement Framed

Dear Mr. Partain:

Thanks very much for your letter of March 16th and for the copy of *National Land Policy*. This is a very fine expression and I think that I shall have it framed and hung on my wall. In my opinion there is nothing more important facing the nation than soil conservation.

CLARK W. THOMPSON, *M. C., Texas.*

The Legume Nodule Story

(Continued from page 82)

on a particular legume grown under greenhouse conditions are frequently unrecognizable under field conditions because of the many other factors which may affect the location, size and distribution of the nodules.

With many legumes under field conditions it has also been observed that during periods of dry weather nodules disappear. When the same crops are examined for nodulation approximately two weeks following rains the inoculated legumes are usually well nodulated again. It is thus possible for a single annual legume crop to produce at least two or three sets of nodules when the soil is alternately wet and dry. Nodulation studies on biennial and perennial legumes under field conditions are very difficult after the first growing season. The nodules the second year and each year thereafter appear farther and farther down on the root systems and are commonly lost in attempting to dig the plants from the soil.

Conclusions

Generalizations associating definite nodulation patterns with degrees of effective symbiosis may be misleading if other factors are not taken into consideration. There is a definite correlation between types of nodulation and effectiveness of rhizobia-legume combination, but this correlation is far from 100 per cent. The true measure of benefit obtained by a leguminous crop from a strain of the root nodule bacteria can best be obtained by studying the top and the seed rather than the root system and nodulation. Nodules must be present on the roots of legumes during most of the growing season if benefit is to be obtained from the inoculation, and they must be present in sufficient volume to furnish the plant all the nitrogen it needs. With most effective strains of bacteria the nodules are usually large, located on or near the tap root and pink on the inside providing soil conditions have been reasonably favorable throughout the growing period.

The mere appearance of nodules in abundance on the roots is not assurance that the bacteria are working efficiently for the plant. Good top growth, a deep green color and high yields combined with heavy nodulation of the root system is good evidence that a high state of symbiosis exists and is the only completely reliable measure of effectiveness.

Attention: **Libraries and Members of The Soil Conservation Society of America**

Back issues of the Journal of Soil and Water Conservation may now be purchased to complete missing numbers in each of the volumes thus far issued.

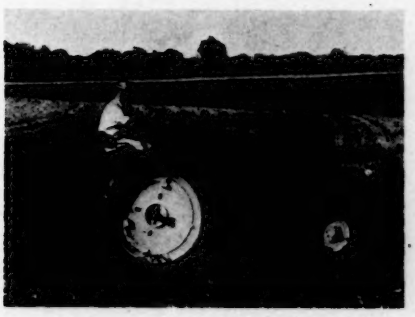
VOLUME 1, NUMBERS 1 and 2 — $1.75
VOLUME 2, NUMBERS 1, 2, 3, 4 — $3.00
VOLUME 3, NUMBERS 1, 2, 3, 4 — $3.00

Direct all correspondence, checks and money orders to —

ALVIN C. WATSON, *National Secretary*
Room 411, Center Building
Upper Darby, Pennsylvania

Built for Conservation Too!

Disk tillers are widely used for terracing, ditching, and filling gullies.



"Powr-trolled" planters, cultivators, tillage tools—designed to protect waterways.

Cornpickers adapted to the contours; rugged combines for terraced, contoured land.

Shown are a few of the many implements designed with an eye to conservation farming. Modern farm tractors, with equipment to match, are truly hastening the day of better soil management everywhere.

John Deere

MOLINE · ILLINOIS

What About the Forward-Mounted

"POPULATION PLANTER" for the 2-ROW FARMALL C?

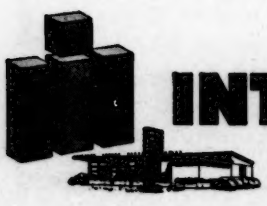
What makes forward-mounting so desirable? You can see what's going on *ahead*, just as with a horse planter—and with the C-220 you plant your crop at today's popular tractor speeds. You can keep your eyes on the guide mark and make rows *chalkline straight* —and also keep the job under observation.

What's the advantage of the clutchless drive? With no clutch, the C-220 planter's seed plates rotate continually at a uniform, even rate. This means extreme accuracy at high tractor speeds. Constant drive means smooth seed plate action and accurate metering of kernels.

How does the C-220 give you "population planting" advantages? You make a simple adjustment of the C-220 planter's seed plate drive to populate a cornfield to its exact fertility level—by checkrow, hill-drop or drill planting. *No other planter built gives you this control.* Fertility level planting gives you top yields and low production costs. And the fertilizer unit for the planter can also be used for side-dressing while you cultivate the crop.

How does Farmall Touch-Control help? With a fingertip touch you can raise or lower the C-220 planter *on the go*. When you raise this planter the markers are raised and the wire is doffed automatically. Nothing to do but turn around!

Where can you get full information? From your International Harvester dealer. See him soon!



This modern building symbolizes the expanded service facilities of IH dealers throughout America.

INTERNATIONAL HARVESTER

180 NORTH MICHIGAN AVENUE • CHICAGO 1, ILLINOIS

LISTEN TO JAMES MELTON ON "HARVEST OF STARS" EVERY SUNDAY AFTERNOON ON NBC.